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EDUCATION

VOLUME 71 No. 8

MATHEMATICS NUMBER

The Pre-School Child's Familiarity with Measurement

What Weights and Measures Should Be Taught in the Elementary Schools?

Industry's Use of Measures

How to Teach High School Students Any Metric Units They Need to Know

Metric Units Needed in College Chemistry

Appreciation as a Teaching Technique

Our Meteorological Detective Story —Tomorrow's Weather

The Measurement of Time

The Thousandth of An Inch in Industry

Weights and Measures in South America

Why the Metric System Didn't Work as a System

A MAGAZINE DEVOTED *to the* SCIENCE, ART, PHILOSOPHY *and* LITERATURE *of* EDUCATION

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EDUCATION

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DEVOTED TO THE SCIENCE, ART, PHILOSOPHY AND LITERATURE OF EDUCATION

VOL. 71 APRIL, 1951 No. 8

MATHEMATICS NUMBER

Denominate Numbers and Measures

GERTRUDE CUSHING YORKE, *Editor*
Assistant Professor of Education
Bucknell University, Lewisburg, Pennsylvania

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EDUCATION

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The Pre-School Child's Familiarity *with* Measurement

By JOSEPHINE H. MacLATCHY

Research Associate, The Ohio State University, Columbus, Ohio

WHEN Dr. Yorke, the Editor of this number of *Education,* asked me to write a short article on the pre-school child's familiarity with measurement, I was happy to comply. My one asset was that I was curious about the matter; my ignorance was complete. Mrs. Swales, Director of Kindergartens in the University School on the Ohio State University campus, from her years of experience with four and five-year-olds had an abundance of ideas but no objective evidence. We decided to pool our resources—her experience and my willingness to do research.

The test we devised has seven inclusive topics: time, liquid measure, weight, long measure, groups of like things (dozens and pairs), money, and miscellaneous items. After a few interviews with children we decided to put most emphasis on time. This topic includes the times of day, the days of the week, months, seasons, and specific hours. The children's information on the other topics proved to be rather vague, and for this reason no other topic is extensively subdivided.

To test the children's familiarity with measuring, two practical tests are included. In the first, the child is asked if he thinks he can find out how many cups of water will be needed to fill "this pitcher" (a pint measure used in cooking). A small pitcher of water is standing on the table nearby with a pile of paper towels to sop up any overflow. Even the three-year-olds have tried this test; very few children have shown lack of understanding by filling the pint measure directly from the pitcher of water. In the second practical test the child stands facing a wall surface and watches while his height is marked on it. He then is asked if he thinks he can show how tall he is, using the yardstick and a foot rule. Most of the children without help overlap the foot rule on the yardstick; several four-year-olds and most of the five-year-olds then count the inches.

In form, the test is chiefly comprised of questions, and each part is generally arranged in a descending order of difficulty. The section devoted to the days of the week follows:

A. Days of Week—

What day do you go to church? .....

What is the name of today?.....

What days don't you go to school? Sa.....Su.....

What other names of days do you know? S..... M..... T..... W..... Th..... F..... Sa..... Named in order? Yes..... No..... *or* Can you say this? S..... M..... T..... Named the three days repeated but went no further..... Named rest in order.....

In the opinion of the writers, the hardest question in this series is the second. Naming the days of the week is often only a feat of memory. A few children can name them in order if given a clue, "Can you say this? Sunday, Monday, Tuesday," urging the child to continue. In filling out the record of an interview, such a start is indicated by 2 in parenthesis after the answer. This means that the child's answer was suggested to him.

Only two of the twenty three-year-olds questioned did not co-operate. Neither of these little boys tried to answer the questions. Each acted silly, evidently from embarrassment in a strange situation, although each of them is generally coherent in conversation with a strange adult. Most of the children enjoyed the tests. Many of them prolonged the interview by recounting personal experiences of various sorts. One four-year-old suggested that she bake a cake after she had successfully filled the pint pitcher with water. Her pantomime was delightful and included even the setting of the oven thermostat. A five-year-old girl, in answer to my question, "How fast does your father drive his car?" said, "I don't know. Would you like to know how fast I can run?" Then she told of an occasion in which she had run beside the family automobile as fast as she could. She finished her story with the remark, "Mother said the speedometer showed that the car was going two miles an hour. That is how fast I can run."

The interview takes at least 20 minutes. Children from several nursery schools and kindergartens and a few private homes in and near Columbus have been interviewed. Since nursery-school and kindergarten children have lunch and rest periods, the time available for testing in each session is short. Generally, not more than three children can be interviewed in one session. The summary of answers includes those of 20 three-year-olds, 28 four-year-olds, and 25 five-year-olds. The table summarized the replies of each year-group is arranged by months; for example, those of four-year-olds are classified under the headings 4.0, 4.1, 4.2, and so on, to 4.11. The number of children in each age-group classified by month of birth is small. In the summary given here, therefore, they are combined in 6-month groups in order to show trends if any are present.

The younger three-year-olds (3.0-3.5) generally could identify *morning* and *night*. Some of the older three-year-olds (3.6-3.11) and most of the younger four-year-olds (4.0-4.5) knew *afternoon*. Half of the older four-year-olds (4.6-4.11) and most of the five-year-olds mentioned *noon*.

Some of the older three-year-olds and most of the younger four-year-olds were somewhat familiar with the names of the days of the week. All the older four-year-olds (19) named the days; eight named them in order. Some of the older fours and younger fives and most of the older fives correctly identified *today*.

The older threes and younger fours

named the calendar and told its use. Occasionally, four-year-olds showed a day on the calendar. Most of the fives identified a day and a week. A few older fives showed a month, knew the year, and pointed it out on the calendar. Still fewer fives knew the number of days in a week although others counted them.

An occasional older three knew the month in which his birthday fell. Half of the older fours and most of the fives answered this question correctly. Although the months of the year were named correctly by one boy of four and a half, no other child did this successfully. The older fives often knew the names of several months.

The seasons are not generally known by the older threes, but one remembered *summer* in November. Eleven of the 19 older fours named the current season corectly; 9 described winter, 7 summer, and 6 fall and spring. The older fives seemed quite familiar with the seasons.

All the children named the clock. The young threes gave its use specifically, "It shows the time to go to bed," while the older children gave general answers as, "When to do things." Scattered children among the four-year-olds and five-year-olds could tell hours on the clock (9:00, 12:00, et cetera).

All the children called the quart bottle a "milk bottle." Supplementary questions led a few older threes to mention *quart*. This answer was almost unanimous with the four and five-year-olds. Very few identified the pint bottle; to most of the children it was "a small milk bottle." Only occasional children identified the half-pint bottle except as a "cream bottle." Occasional four-year-olds and most of the five-year-olds mentioned *gallons* in telling how their fathers asked for gas. A few children in each year group were not able to determine the number of cups of water needed to fill the pint pitcher. The majority in each age group, however, did this successfully, and many were most careful to pour the water up to the lines marked on each utensil. Several of the older threes used the words *weigh, scales,* and *pounds* in talking about their own weight. Some of the older fours and most of the fives also used these words in describing the transaction of buying meat.

The younger three-year-olds called the yardstick and foot rule "measuring sticks" and said their use was "to measure." The four and five-year-olds said their use was to find out "how long" or "how tall" something was. A few said the use was "to paddle kids." An occasional three-year-old and most of the fours and fives were able to show their height by overlapping the yardstick with the foot rule. A few of the older fours and a larger proportion of the five-year-olds counted the inches; some of them started to count the extra inches on the foot rule with 37. In reply to, "How fast does your father drive his car?" occasional four-year-olds mentioned *miles*. Most of the fives used this term, and some gave the rate in "miles per hour."

The word *pairs* was easily elicited from the four-year-olds who were able to tell how many made a pair, said they looked just alike, and named things that came in pairs. *Dozen* was known by a few four-year-olds and a larger proportion of the five-year-olds, but only an occasional child knew the number in a dozen. One four-year-old said, "I've counted them (eggs in a carton) before now," but she did not remember how many there were.

All the children were familiar with money. Only one child called the miscellaneous collection "pennies." All knew its use, but three-year-olds were specific in defining it "to buy groceries, yummies, snowsuits," et cetera—while the fours and fives said "to buy things." The *penny* was most familiar. Several older three-year-olds identified the *penny, nickel,* and the *dollar bill.* A larger proportion of the four-year-olds named these denominations and identified the *dime.* Some of the five-year-olds knew all of them. One of the older three-year-olds knew that the nickle would buy more candy than the penny, and the dime more than the nickel. This was known to some of the fours and more of the fives. The number of pennies the man in the bank would give for nickels and dimes was not commonly known, although two of the older four-year-olds answered this question correctly as did several five-year-olds.

The three-year-olds were familiar with the clinical thermometer but none of them called it by name. Most of them called it a "temperature." Some of the young four-year-olds recognized the wall thermometer and knew its use. The fives were more familiar with the use of both. Several five-year-olds explained how the wall thermometer showed *hot* and *cold,* and one used the word *degrees.*

"Dump trucks" were described in telling how coal came to some houses —even by three-year-olds. One of them when questioned used the word *tons.* Several four and five-year-olds also used this word. No one knew about gas meters. Only one child used the word *watts* in talking about light bulbs.

The results show that the children's familiarity with measures of time is more inclusive and more meaningful than their familiarity with the conventional measures. They have learned to notice changes in their natural environment and to identify them by the terms used. Although one older three-year-old remembered summer in November, none of the other threes seemed to remember differences in seasons or to impute any significance to changes in their clothing or in their outdoor surroundings. Older fours and fives were quite familiar with the seasons. *Noon* is later identified than *morning, night,* or *afternoon.* Of course, they have still to learn the exact meaning of 12:00 noon.

What do we conclude from all this? Simply that out of "the big, booming, buzzing confusion" of sounds which surrounded them in their infancy, these pre-school children have heard these words and remember the context in which they were used. Even the little girl who ran "two miles an hour" did not really understand what she said, but she had the beginning of understanding. She related the two terms properly, and she understood the context from which she got them. Not all these children have listened with equally good effect. According to several of them: Mother asked the grocer for "some meat," Father asked the filling station man for "some gas." More often, however, the children listened and heard *pounds* and *gallons.*

What these children have acquired is the terms used and in some cases, notably time, their understanding has content. Their familiarity with *quart, gallon, pounds, coins,* and the like, has no real content. They simply recall words or phrases in their habitual context.

What Weights *and* Measures Should Be Taught *in the* Elementary School?

By CLAIRE FRANCES EDDY

The South School, New Canaan, Connecticut

What is Measurement?

LENNESS[1] answered the question as follows: "Measurement is the process of determining the magnitude of a quantity by finding how many times a fixed unit of measure is contained in it. The process consists in dividing the quantity to be measured into parts, each equal to the unit of measure, and then counting the number of parts."

What is the importance of measurement?

Hubbard[2] says: "Measurement is the Master Art. Measures tell how Nature behaves and how to control her mighty forces in the service of man. Through measures of sun and moon, their place, mass, and motion, we predict the tides on which commerce rides with her argosies to all the world. Men go by land, sea, and air, night and day, unceasingly guided by measuring instruments which tell the tale of speed, place, direction, and power. Transit is 'made to measure.'

Explorer and surveyor locate position by measuring the height of the stars. The map is a fabric woven of latitudes and longitudes. On it the facile pencil of the engineer creates a new earth. His dreams come true because the workers, from survey to steam roller, work true to measure.

The mariner still hitches his wagon to a star, for measurement was born among the stars. The star-gazing dreamers of yesterday gave us astronomy, chronometry, the calendar, surveying, geometry, and the art of navigation.

Modern science began with measurement. We measure the rock to recreate the timetable of geology. We measure tree rings to learn the life story of the tree, and through measures these tongues in ancient trees retell climatic history centuries past.

To science, measurement is a means of discovery, prophecy, control. To industry it is the tool of creation. The measured curves of every tool are alert with the skill of a race of craftsmen. The machine is a complex of measures which sets each craft to cosmic power.

All industry measures to serve. Its every deed fits a measured need, whether size, strength, color, or whatever gives utility to things. Industry is service set to measure. We measure the body to clothe it with measured apparel. Our life itself fits into measured schedules of time and place.

Measures are the life of the fine arts —poetry sings in measures, sculpture carves them into inspirations, architecture enshrines them, and the measured record of tones and silence, their sequence and concord, transmutes the

1 Lenness, N. J., *The Teaching of Arithmetic*, p. 278, The Macmillan Company, New York, 1929.

2 Hubbard, Henry D., An address reprinted in the official organ of the Metric Association, the quarterly journal, *Measurement*, October, 1925.

soul of the master musician into vibrant harmonies for the joy of the world.

Measurement is a miracle worker. We give a measured curve to glass to match a measured defect of the eye, and restore sight to the aged and perfect the vision of youth.

Perfect measurement is a perfect truth, and sets man free. Everywhere measurement is busy creating the tomorrow of our dreams. Measurement is the master art. It has but one purpose, to create the maximum happiness for all."

What Measures do people know?

This question was answered very effectively by Dorothy W. Wilson in a Master's thesis at Boston University in 1936, and later reviewed in "Educational Method," pp. 177-181, January, 1937. Her study checked the common knowledge of measures of 2,819 children and adults. Results showed that: (1) experience and use are the factors which determine the measures or units of measure that are known by children and adults; and (2) teaching denominate numbers and measures in school has small effect upon later knowledge unless reinforced by experience and use.

Should measures be taught in the elementary school?

Klapper[3] says: "Units of measure must be included in the course in arithmetic because they are daily media of evaluation and exchange."

He believes the following should be the work of the elementary school:

1. Linear Measure—inches in foot and yard, feet in yard, feet in mile

2. Liquid Measure—gill, pint, quart, gallon.

3. Dry Measure — pint, quart, peck, bushel

4. Avoirdupois Weight — ounce, pound, hundredweight, ton

5. Time—second, minute, hour, day, week, month, leap year

6. Money — United States currency, the pound sterling, the franc, the lira; and their approximate value in dollars and cents

7. Surface and Volume Measures —square inch, square foot, acre, cubic inch, cubic foot, cubic yard

8. Metric System—in the junior high school and as part of the work in science

9. Useful facts—not part of any traditional table.

Elementary school arithmetic should include only those weights and measures which are used by people in daily activities.

What measures are used by people in daily activities?

Before undertaking a study of measures in a sixth grade of The South School, New Canaan, Connecticut, it was decided to check each family's use of measurement for one week. Letters were written to Mother and Dad explaining the plan; booklets were made for recording daily use of measure. Since New Canaan is a residential town from which people commute to New York, occupations are varied, and the typical problems of commuting are frequently reflected in home and school activities. Fathers engaged in advertising, sales management, writing, pipe-fitting, television production, building, gardening, banking, art, in-

3 Klapper, Paul, *The Teaching of Arithmetic*, p. 409, D. Appleton-Century Company, New York, 1934.

vesting, caretaking, and law practice responded to the children's request for information, and faithfully did their homework. Most mothers occupied with activities outside the home were employed in offices.

A break-down of returns showed that in regard to:

1. Linear Measure—the use of inch and fractional parts far outdistanced other measures of length. One father added a touch of humor to his record by reporting that he buried a rat 8 inches deep after killing it with a 3-foot club! Mileage by car, train, or plane was noted next in frequency.

2. Liquid Measure—cupfuls used by Mother in cooking were recorded more than any other measure and gallons used in buying gas and heating oil were next.

3. Dry Measure—cupfuls far outnumbered use of teaspoon, pint, quart, peck, bushel; tablespoon (used often for measuring coffee) showed second.

4. Avoirdupois Weight—almost all notations were in pounds; few mentioned ounces; no one referred to hundredweight or ton.

5. Time—speed limits were observed; cooking times were listed; one father used a stop watch to measure number of words in a radio commercial; one mother figured time for a baby-sitter; checks were made of time it took to walk or ride between certain points; the New Canaan Railroad timetable was consulted.

6. Money—United States currency only was used.

7. Surface and Volume Measures—one father laid a 20-foot by 4-foot concrete sidewalk; another measured plans for heat loss in square feet of radiation; another enlarged his garden area; one used a compass and protractor to determine area covered by a radio station in Minnesota; a mother cleaned a 12-foot by 15-foot rug and waxed a 10-foot by 15-foot floor.

8. Metric Measures—none were used.

9. Useful Facts—appeared more often than any others.

Temperatures
- Oven
- Room
- Deep-freeze unit
- Boiling point

Clothing, shoe, and hat sizes

Sewing and Knitting
- Numbered spools of thread
- Skeins of yarn
- Numbered knitting needles

Measurement of distance by blocks; by floors in buildings

Commodities
- Light bulbs by number of watts
- Difference in can sizes
- Carton of cigarettes
- Carton of root beer
- Hand of bananas
- Head of lettuce
- Bunch of celery
- Dozen eggs
- Box of cereal

Camera measures
- Set camera for snapshot; aperture 3.5 millimeters; exposure 1/5 second; distance 9 feet

Although the findings were limited, distinctly local, and based on parental replies from one classroom for a week, it would seem that this particular elementary school should consider teaching:

1. Linear Measure—inch, foot, yard

2. Liquid Measure—cup, pint, quart, gallon

3. Dry Measure—teaspoon, tablespoon, pint, quart, peck, bushel
4. Avoirdupois Weight — ounce, pound
5. Time—second, minute, hour, day, week, month, year
6. Money—United States currency only
7. Surface and Volume Measures —square inch, square foot, acre
8. Useful Facts.

Since experience and use are the factors that determine how adults handle measures, elementary schools should eliminate drill in: (1) addition, subtraction, multiplication, and division of compound numbers; and (2) rote memorization of tables. If curricula replace meaningless practices with plans for developing appreciation of measurement's importance in the modern world, and if they provide extensive experience in using measures for which children have need, tomorrow's adults will have a better understanding of useful measurement.

BOOK REVIEWS

Reviewed by WILLIAM P. SEARS, Jr.

Sacred Music. By Alec Robertson. New York. Chanticleer Press. 1950. $2.50.

This rather brief consideration of sacred music is from the pen of a Britisher who is well known in his own country as a broadcaster and lecturer. He is also internationally respected as an authority on Gregorian chant. He writes, in this essay, on the development of medieval plain chant, and on the church works of Bach, Haydn and Mozart. The book also records how Martin Luther returned to the ideal of the early Christian Fathers when he organized the music of the "Reformed" church on the basis of community singing. English composers, from Byrd to Ralph Vaughan Williams, receive especial stress. Illustrations include examples of illuminated psalters, missals, and manuscripts. — WILLIAM P. SEARS, Professor of Education, New York University.

Achieving Maturity. By Jane Warters. New York. McGraw-Hill Book Company. 1949. XI and 349 pages. $3.00.

This book, written in non-technical language, covers the principal developmental experiences of adolescents and youth in the areas of physical, intellectual, emotional, moral, ethical, interpersonal, and social growth. The author includes the findings of some of the most recent research studies on adolescence and youth, and there are presented comprehensive pictures of the major aspects of achieving adult status and maturity in our society. Young people will find much in this book to help them understand the nature of their problems and to assist them in utilizing sources of aid and in acquiring knowledge of certain fundamental principles of guidance and mental hygiene.

The Colonial Craftsman. By Carl Bridenbaugh. New York. New York University Press. 1950. $4.25.

Craftsmen formed a large and crucial group in American colonial society and, curiously enough, their story has never been written. In this book, composed of the 1950 Anson G. Phelps lectures at New York University, the fascinating history of the American cabinetmakers, silversmiths, pewterers, printers, painters, engravers, blacksmiths, brass-button makers, hat makers, shoemakers, clock makers, and a host of "female" artisans is vividly told by Carl Bridenbaugh, the Director of the Institute of Early American History and Culture at Williamsburg, Virginia.

Industry's Use *of* Measures

By VINCENT SALA
Principal, Senior High School,
New Britain, Connecticut

CONTROVERSY still exists as to what should be taught in arithmetic in the field of measurement. Research conducted by Dr. Guy M. Wilson[1] shows that many requirements in the curriculum are of little or no value in everyday life. Conflicting points of view continually challenge those who advocate the elimination of apparently useless materials. Statistical data, however, demonstrates that some phases of measurement may well be eliminated, releasing time to teachers and pupils for other endeavors. Such data were secured by the writer in industry where exploration was made to determine what measures are needed by thousands of employees in the city of New Britain, Connecticut. A survey was made of four leading New Britain industries: Fafnir Bearing Company, manufacturers of precision products; the Stanley Rule and Level Company, manufacturers of builders' tools; P. and F. Corbin Company, makers of builders' hardware; and the Vulcan Iron Works, a casting concern. The four industries chosen show a spread from a company requiring high technical skills to one involving manual work with little demand beyond physical strength.

The first step in this study was to determine the amount of knowledge of measurement used in routine industrial work. In order to separate the employees using accurate measures from those who do not need great accuracy of measurements to carry on their daily work, the following classifications were made:

First Class: Men who have expert knowledge of the unit of measure gained in a technical school, or from experience and use. Such are die-cutters, facing operators, et cetera, who measure with micrometers, vernier calipers, and other sensitive instruments, and who employ special formulae and techniques for measuring accurately all types of work. This demands special training and a minute degree of accuracy to tolerances[2] of ten-thousandths (.0001) of an inch.

Second Class: Men who require a knowledge of the common measure, such as linear, square, and cubic, and who are able to read simple blueprints. This kind of work involves measuring the inch and foot accurately, but does not necessitate measuring parts of an inch accurately.

Third Class: men who do not need to understand any units of measurement. Such individuals are engaged in press work, polishing, trucking, et cetera, where machines are automatic and the process, though important, does not demand the use of measurements.

The second step was to determine

1 Wilson, Guy M., Mildred B. Stone, and Charles O. Dalryample, *Teaching the New Arithmetic*, McGraw-Hill Book Company, Inc., New York, 1939.
2 Fractional allowance for variation from standard.

the measurements used in purchasing raw materials, in manufacturing, and selling products. These in turn were checked with the following tables of denominate numbers: Avoirdupois (8 units), Linear Measure (10 units), Square Measure (10 units) Cubic Measure (8 units), Paper Measure (16 units), Measures of Angles and Arcs (8 units), Unit Measurements (10 units), Metric Denominations (20 units), Measure of Metric Length (16 units), Board Measure (1 unit), and Liquid Measure (10 units), making a total of 67 units to be checked with measurements used in four industries.

Specific findings in the four industrial concerns reveal considerably less demand for knowledge of measures than most schools require, as the following summaries show.

1. *Fafnir Bearing Company*

This particular and unusual industry showed a large number of men requiring an accurate knowledge of measurement in metric units down to millionths (.000001) of an inch with the metric micrometer. These men were trained in the factory in the use of the finer type of measuring instruments. A recheck in 1950 shows that 25% of the men are in the first class; the percentage of men falling in the second class is 50%; and 25% are in the remaining third class. The dimensions noted in this part of the study are those of manufacture and involve metric units. For the convenience of purchasers, however, the inch is usually given beside the metric measurement. This holds true of standard stock. This company employs nine tables of denominate numbers, but *never* is a table used in its entirety. The actual breakdown is:

a. Purchasing: metric (length and weight), avoirdupois, cubic, unit, board, volume, square, and linear.

b. Manufacturing: metric (length).

c. Selling: metric (length) and linear.

2. *P. and F. Corbin Company*

This concern at the time of the writer's study employed 1,498 men, of which 11% were in the first class; 2% in the second class; and 86% in the third class. The majority of men employed in this company fall in the third class because practically no work in measurements is required. The average shop-man is a feeder to the machines. In this particular industry the experts are the only men who need a knowledge of measurement. They set the machines. This company uses seven tables of denominate numbers but again, never in their entirety. The tables are:

a. Purchasing: avoirdupois, unit, linear, liquid, board, metric (weight), and paper.

b. Manufacturing: linear, avoirdupois, and unit.

c. Selling: linear, avoirdupois, and unit.

3. *Stanley Rule and Level Company*

This is a relatively small concern, employing only a few over 500 men. According to the classifications set up 19% were in the first class: 9% in the second class, and 71% in the third class. These percentages are somewhat similar to those of the P. and F. Corbin Company. The work in this industry does not require a minute degree of accuracy on the part of the employees because, as in the Corbin Company, the majority of the men need no knowledge of measurements

since the machines are set by inspectors or foremen. All that is required of the workman is feeding a machine. This factory, also, does not use an entire table of denominate numbers, but only one or two units. Thus:

a. Purchasing: avoirdupois, unit, liquid, metric (weight), cubic, linear, board foot, and paper.

b. Manufacturing: linear, avoirdupois, unit, and angles.

c. Selling: linear, avoirdupois, unit, and angles.

4. *Vulcan Iron Works*[3]

This concern, which manufactures castings, demands considerable manual skill on the part of the worker, but out of the 202 men employed, only 7% were in the first class; 5% in the second class; and 86% in the third class. Two specialists out of the 200 employees need measurements for purchasing and manufacturing. Again the entire table of denominate numbers is never used, but only seven units. These are:

a. Purchasing: avoirdupois, cubic, board, unit, and gallon.

b. Manufacturing: avoirdupois, board, liquid, cubic, and unit.

c. Selling: avoirdupois, board, liquid, cubic, and unit.

In this study 278 products from purchasing, manufacturing, and selling were followed through from origin to completion. Over 3,000 employees were involved. The data here presented may be summarized as follows:

1. Out of 67 possible units in the 11 tables of denominate numbers used by four companies in manufacturing, purchasing, and selling, only 18 units were used.

2. Over 68 per cent of the employees did not need to know or even understand any units of measurements.

3. A table of measurement is never used in its entirety. Only one unit of measurement is necessary as a rule for any one purpose. For example, those men who work in the factory using the inch or part of an inch seldom have occasion to use the yard.

4. The units of measurement used in the purchasing of raw materials differ from those used in manufacturing. The units used in the former are usually those of volume and capacity, while linear measurements showed greater frequency in manufacturing.

5. In the four industries studied, the inch and the pound were the most common units of measurements for manufacturing and selling; the pound rating second in frequency.

6. Whatever degree of accuracy is commonly called for, that degree of accuracy becomes the unit of measurement in the operation involved.

7. A knowledge of tolerances (fractional allowance for variation from standard) involved only the men who are experts, usually designers and those employed in the engineering department. In the Fafnir Bearing Company a large percentage of men were in the classification of those needing to know fine measurements. Tolerances, however, are usually of concern only to the engineers and designers. Others use gauges which measure tolerances as for example the Fafnir gauges marked "Go" and "No go," but these workers do not need to understand the actual measurements involved. The data of this study justify the conclusions that:

1. *The teaching of addition, sub-*

3 Now located in New Haven, Connecticut.

traction, multiplication, and division of compound denominate numbers has little practical value for the learner. In the four industries studied no use was found for these processes.

2. *The memorizing of tables of weights and measurements has little value.* Complete tables of denominate numbers are not used by any one of the men employed in the industries studied. When a pupil has once actually purchased an article, it should not be difficult for him to apply the preferred unit of measurement to that particular article on ensuing occasions. It is important for the pupil to know commodities; the unit of measurement follows.

3. *Reduction ascending and reduction descending as processes have little or no justification for continuation as exercises in the arithmetic of our schools.* With the exception of in the cost department which makes estimates on various "jobs," reduction ascending and reduction descending have no value or place in the industries studied. Work involving these processes was confined to six men.

Should our schools continue to teach subject matter which has no use in life?

CHILDREN'S BOOKS

Reviewed by CECILIA SATTELY

Dandy the Donkey. By Walter Trier. New York. Dodd Mead & Co. 1949. 46 pages $1.75.

This charming tale of a loveable donkey will be a favorite for any child of the picture-book age.

Dig For A Treasure. By Dean Marshall. Illustrated by Christine Price. New York. E. P. Dutton. 1949. 188 pages $2.50.

Children from eight to eleven will enjoy this tale of adventure and hidden treasure.

Sphinx, The Story of a Caterpillar. By Robert M. McClung. Wm. Morrow & Co. 1949. 46 pages. $2.00.

A scientist takes time out from his regular duties to write a picture-story of the growth of a caterpillar from pupa to moth, and does a beautiful job for the 5-8 year olds.

Snakes. By Herbert S. Zim. New York. Wm. Morrow & Co. 1949. 70 pages. $2.00.

Adventurers from 8 to 14 will enjoy this accurate and interesting book on the lives and habits of snakes.

Play With Plants. By Millicent S. Silsam. New York. Wm. Morrow & Co., 1949. 63 pages. $2.00.

A science picture book for elementary school. This book will also prove valuable as a source book for the handicapped or bed-ridden child.

The Size of W. By Ethel S. Berkley. New York. William R. Scott, Inc. 1950. 25 pages. $1.00.

Brief, clear, illustrated treatment of the basic concepts: little, big, long, tall, wide, narrow, and short. Very suitable for room corner libraries, grades one or two.

—GUY M. WILSON

How *to* Teach High School Students Any Metric Units They Need *to* Know

By STANFORD L. KUNKLE

Principal, High School, Milton, Pennsylvania

THIS discussion might be opened with a question, "Does 'Any Metric Units They Need to Know' mean for use in daily living, or does it mean units needed in the study of high school physics and chemistry?" If the former is meant, then the answer is that students do not need to know about any metric units, because they are not generally used in our country; but if the latter meaning is inferred, then the students who elect these two subjects must become acquainted with metric units.

In all good teaching one proceeds from the concrete to the abstract; from the old to the new. In the metric system there are basically two units of measurement—length and weight. Two others, area and volume, might be included although they are derived from units of length. Let's start with the unit of length. There are measuring sticks available one meter long. On one side are metric units (centimeters) and on the other side are English units (inches). Showing such a stick to the class and asking what it represents will usually bring the response, "yard stick." This is a natural answer since it looks like our yard stick. By means of the inch marks on this stick, it can be shown that it is approximately 39⅜ inches long, and is called a meter in the metric system. Thus the first metric unit is compared to a familiar English unit that is commonly used. At this point it should be emphasized that the meter is a little longer than a yard. Other units, both larger and smaller, needed for measuring are derived from the basic unit, the meter.[1] By learning eight prefixes; dimilli, milli, centi, deci, deca, hecto, kilo, and myria, a student knows the entire metric table of length. The units most used, however, are: the millimeter, the centimeter, and the meter. English-metric equivalents that should be memorized are:[2] 1 inch=2.54 centimeters, and 1 meter=39.37 inches.

In chemistry and physics, the metric unit of volume, the liter, is used. This can easily be taught by means of a "litre" block (available from labora-

1 The meter is first divided into 10 parts, each part being 1/10 meter. Each 1/10 meter is then subdivided into 10 parts, each being 1/100 meter. Each 1/100 meter is again subdivided into 10 parts, each being 1/1000 meter, and each 1/1000 meter is subdivided into 10 parts, each being 1/10,000 meter. These smaller units are named by attaching prefixes to the word meter. From the Latin dimilli means 1/10,000; milli means 1/1000; centi means 1/100; and deci means 1/10. Thus beginning at the smallest unit we have: dimillimeter (1/10,000 meter), millimeter (1/1000 meter), centimeter (1/100 meter), and decimeter (1/10 meter). For larger units, other prefixes are used: deca (10), hecto (100), kilo (1000), and myria (10,000), giving decameter (10 meters), hectometer (100 meters), kilometer (1000 meters), and myriameter (10,000 meters).

2 1 kilometer=.62 mile (for use in mathematical problems).

tory supply houses). It is made of wood and is marked off in centimeters. It is 10 x 10 x 10 centimeters in size or 1000 cubic centimeters in volume. The top portion of this block is a separate piece which is 1 centimeter thick and 10 centimeters square. One tenth of this top portion can be removed and shown to the students as a section 1 centimeter square and 10 centimeters long. This, in turn, is made up of a one centimeter cube and a section 9 centimeters long. The centimeter cube can be passed around the class so that the students may get an idea of the size of a cubic centimeter. Liquids and solids are measured in cubic centimeters. Then by means of each of the parts of the block it can be shown how the entire block is made up of 1000 cubic centimeters. From the liter, the metric units of volume are derived by using the same prefixes mentioned above. The most useful units are the cubic centimeter and the liter, whose respective equivalents are: 1 cubic centimeter=1 milliliter[3] and 1 liter=1.06 quarts.

The gram is another metric unit that should be taught. A comparison of sets of English and metric weights is helpful here. The English-metric equivalents can be shown by balancing grams against the ounce, or more important the kilogram against pounds and ounces. The relationship to emphasize at this point is that 1 kilogram=2.2 pounds.

The other two basic units, the are and the stere,[4] should not be taught at the high school level, as they are not needed in laboratory work. Thus out of the 45 units of the original metric system (1792) only *8* are needed in high school physics and chemistry. These are: the meter, the centimeter, the millimeter, the gram, the kilogram, the milligram, the liter, and milliter which is 1.000027 cubic centimeters.

3 Strictly speaking, 1 milliliter=1.000027 cubic centimeters.
4 1 are=3.954 square rods;
1 stere=¼ of a cord.

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Metric Units Needed *in* College Chemistry

By HAROLD WARREN HEINE

Assistant Professor of Chemistry, Bucknell University, Lewisburg, Pennsylvania

THE measurements employed in chemical processes which depend upon metric units are far too numerous to describe in a single paper. To avoid subjecting the reader to an unduly prolonged discussion of the use of metric units in chemistry only a few typical measurements have been selected for discussion. The importance of certain metric units to the chemist, however, will become apparent as the reader notes their recurrence in many basic chemical principles.

Very often in analytical chemistry it is possible to determine quantitatively the percentage of a compound by a titration. This is the process of permitting two solutions to react with each other under such conditions that the end of the reaction may be recogznied. The volume of at least one of these solutions is measured accurately using the *milliliter*[1] as a unit of volume. Such titrations usually are accomplished with the aid of a standard solution, in other words, a solution whose concentration is accurately known. The concentration of a standard solution can be expressed in terms of molarity or normality. Molarity[2] is defined as the number of *gram* molecular weights of a substance per *liter* of solution. Normality[3] is the number of gram equivalents weights of a substance per liter of solution.

The existence of useful analytical principles based on these particular units of concentration of molarity or normality are widespread. The concept of the solubility product so useful in its application to the formation of precipitates may be cited. This constant[4] is equal to the product of the concentrations of ions (expressed as the number of gram ions per liter) in a saturated solution of a relatively insoluble salt, such as silver chloride.

Other chemical principles attendant upon the units of concentration outlined above are the ionization or dissociation constants of weak acids. The strength of weak acids are measured

1 1 ml. equals 1.000027 cubic centimeters.

2 $\text{Molarity} = \frac{\text{Gram molecular weights}}{\text{Liters}}$

3 $\text{Normality} = \frac{\text{Gram equivalent weights}}{\text{Liters}}$

4 The constant is expressed as follows: $K_{SP} = [Ag^+]\,[Cl^-]$. K_{SP} is the solubility product constant. $[Ag^+]$ is the molarity of the silver ions. $[Cl^-]$ is the molarity of the chloride ions.

according to the extent of their dissociation and are expressed by the dissociation constant.[5]

The characteristic properties of an acidic solution are due to the presence of hydrogen ion, H^+. The measurement of the concentration of the hydrogen ion of a solution constitutes one of the most common practices of any chemist. It is customary to express the hydrogen ion concentration in terms of pH.[6]

A concentration term (molarity) is also employed to measure the electromotive force between a metal and a solution in which it is immersed. The German chemist, Nernst, succeeded in deriving an equation which shows this relationship.[7]

Other ways in which the metric units (grams and milliliters) are used to express concentrations other than molarity and normality are important to the chemist. For example, a weight-volume term that enjoys much usage among chemists is density. The density of a substance is its weight in relation to its volume. In chemical work, the density of a substance is usually expressed in grams per milliliter.[8] The measurement of density is commonly employed by the garageman to evaluate the anti-freezing properties of radiator fluid in automobiles during cold weather.

The molecular volume (the volume of one mole) is $V=M/d$, where M is the gram-molecular weight and d the density. The molecular volume and density of liquids and solids are dependent upon the arrangement of the atoms in a molecule. The study, therefore, of density or molecular volume, sometimes allows conclusions to be drawn about the intra-molecular arrangements of atoms.

The surface tension of a liquid (the tendency of a surface to contract) is related to its density. One of the methods of measurement of surface tension depends on the rise and fall of a liquid in a capillary tube and can be calculated by the equation:

$$\delta = \tfrac{1}{2}\ \text{hdgr.}$$

where δ is the surface tension, h is the height in *centimeters* in which the liquid rises in the tube of a radius of r centimeters, d is the density and g the gravitational pull in centimeters per second per second.

One other example will suffice to illustrate the applicability of density to the chemist. The Clausius-Mosotti equation which shows a measure of the ease of displacement of positive and negative charges with respect to each other in an electrified field, is as follows:

$$P = \frac{\epsilon - 1}{\epsilon - 2}\,\frac{M}{d}$$

5 $\dfrac{K=[H_+]\ [B]}{[HB]}$ where K is the dissociation constant, $[H^+]$ the molarity of hydrogen ions, [B] the molarity of the conjugate base and [HB] the molarity of the non-ionized acid.

6 The pH is the negative common logarithm of the hydrogen ion concentration: $pH = -\text{Log}\,[H^+]$.

7 $E_1 = E^o + \dfrac{0.1983T}{2}\ \log M$. E_1 is the electromotive force between the electrode (the metal) and the solution. E^o is a constant, T the absolute temperature and M denotes the molarity of the cations of this metal in the solution.

8 $\text{Density} = \dfrac{\text{Mass (grams)}}{\text{Volume (milliliters)}}$

where P is the molar polarization, M is the gram molecular weight and d is the density.

Most of the preceding discussion has involved metric units of weight and volume but a host of other chemical or physical measurements are dependent upon units of length. An important measurement that involves length is the rotation of plane polarized light. Some materials when placed in the path of a beam of polarized light (light waves vibrating in a specific plane), possess the property of rotating the plane of polarization to the right or left. The extent of the optical rotation depends on several factors including the nature of the substance, the length of the column through which the light passes, the wavelength of the light and the temperature. In solutions it depends also on the concentration of the solute. The specific rotation is defined:

$$\left[\alpha\right]_t^{\lambda} = \frac{\alpha}{l c}$$

where $\left[\alpha\right]_t^{\lambda}$ is the specific rotation, α is the observed rotation, 1 is the length of the column in centimeters, and the concentration C is expressed as the number of grams of optically active material per milliliter of solution.

Molecules have the property of absorbing light of various wavelengths. Use of this absorption data in attacking problems of structural organic chemistry has been very fruitful. The wavelength of light is measured in Angstrom units.[9] One Angstrom (A°) is one millionth (10^{-8}) of a centimeter. Light is also described in wave numbers which are expressed in reciprocal centimeters.

The frequency of light, obtained by multiplying the wave number by the velocity of light (3×10^{10} cm/per second) is important in photochemistry and in energy calculations. The energy in one quantum of radiation is given by the fundamental quantum relation $\epsilon = h\nu$. Relationships such as these are useful in computing the tremendous energy expended by atomic bomb explosions.

The dipole moment is another example where a metric unit of length is used in chemistry. Molecules are composed of positive and negative charged particules in such numbers that they are neutral as a whole. In polar molecules there is a finite distance of separation between what may be termed the centers of gravity of the positive and negative electricity. When placed in an electrical field a polar molecule will tend to orient itself in such a way that the positive part of the molecule points toward the negative electrode. The force required to orient the molecule will depend on the magnitude of the charges and on the distance between them. The dipole moment is defined as the product of one of the charges and the distance (in centimeters) between the two average centers of positive and negative electricity.

In scientific work, measurements of pressure of gases are usually referred to in terms of *millimeters* of mercury. For example, a pressure of 720 millimeters (mm.) would be a pressure equal to that exerted by a column of mercury 700 millimeters high.

9 A chemist occasionally finds it convenient to use a logical extension of a metric unit to express a very small number.

The use of the 5 metric units mentioned above: the gram; the liter and milliliter; the centimeter and millimeter throughout the field of chemistry is apparent from the illustrations that have been cited. The meter, the kilogram, and the milligram also are used extensively. Three factors contribute to their popularity among scientists. First, metric units are interrelated; second, the remarkable ease with which calculations are made; and third, the units are international. The other 38 metric denominations[10] such as, myriameters, hectograms, et cetera are rarely employed, if at all.

10 There are 8 possible combinations for each of the 5 basic units: the meter, the are, the stere, the liter, and the gram, not including the franc.

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Appreciation *as a* Teaching Technique

By GUY M. WILSON
Boston University, Boston, Massachusetts

DISCRIMINATING teaching has not been the rule in American schools, nor in many schools the world over. The rule has been one idea at a time, and when a new idea comes along, adopt that and discard the old. This applies to the progressives; the rank and file never change. They use drill interminably, in all teaching.

There are three *major* teaching techniques; drill, problem, and appreciation.

Drill is the technique to use when the aim is perfect response on much-used material, such as the addition facts, the correct spelling of much-used basic words, correct language forms, writing, basic skills, and games. Drill is frequently begun too soon and extended too far. There should always be good understanding, real need, and adequate motivation; drill should never proceed without these. Probably three-fourths of the drill work of the schools of today is inapplicable or ineffective. In arithmetic, drill can be set up in sizable units and made interesting and attractive, but it should be limited.

In early America, drill was the universal method. Drill was applied to the catechism, to spelling, to writing, and later to geography, history, physiology, grammar, and nature study. Memory was the sole reliance. The drill technique when applied to problem and appreciation types of subject-matter has deadening, detrimental effects.

The problem technique should teach people to think, on the basis of facts and data. It is applicable to some phases of history and geography, and to science. Facts need not be memorized, merely collected, arranged and studied. The conditions in politics and the results in elections, indicate that most people in America are incapable of problem thinking. Politicians get by with double talk, misrepresentations, false promises, appeals to prejudice, and actual lying; they find these tools of Russian propaganda more effective than trying to get people to think in terms of facts and data. The schools must confess to a large measure of failure in the proper development and use of the problem technique. The usual so-called problem work in arithmetic is merely disguised drill; teachers need help in the development of real problem units in arithmetic.[1]

The appreciation technique is unknown to the majority of teachers. Its aims are enjoyment, favorable attitudes, reference acquaintance, and the

1 Wilson, Guy M., Mildred B. Stone, and Charles O. Dalrymple, *Teaching the New Arithmetic, Part* III, "Written Problem Units." See also *Education*, February, 1949, for brief reports on several problem units.

development of permanent interests. It is probable that fully one-half of all school work in grades and high school should be in the form of appreciation units. They are possible in any subject, in marked contrast to the limited possibilities of drill and problem units. The remainder of this article is devoted to the analysis of the appreciation technique as a teaching process.

The Appropriate Subject-Matter. The early thought on appreciation was that appreciation units were possible only in the fine arts—painting, music, architecture, literature. These were considered to be the "cultural subjects." It was soon realized, however, that many people were not interested in these subjects. Are they, therefore, devoid or deprived of culture? The answer is obvious. Culture may be found in any field or subject. The student of history, science, or mathematics may also reach for the stars. The cultural, appreciation opportunities are there. Any student in any subject may want to carry forward to the appreciation level. The purposes of appreciation are preparation for leisure, enjoyment, desirable permanent interests. It gives to life that broadness and richness which after all makes it really worth while.

The Technique of Appreciation. In the past teachers have too frequently applied the wrong technique to such subjects as literature, music, painting and appreciation units in other subjects. It has been all too common to make poetry a drill process, committing to memory without understanding; or a process of rational dissection, frequently far beyond the ability of the child to comprehend. Neither of these procedures is correct, although after appreciation of a poem has been established, pupils may choose to memorize it, and do so with much enjoyment, if properly guided by a competent teacher. Pupils may also be interested in a few of the fundamental reasons why a poem is superior, but it is not well to emphasize either the drill work or the rationalizing in subject matter such as poetry. Appreciation is dependent upon the feelings rather than the intellect. The technique is entirely different from the technique of problem solution or of drill. Four definite steps are recognized in the technique of appreciation:

(1) *Creating an Atmosphere of Interest.* This is the provision for motivation so essential in any good teaching, but the procedure in appreciation subject-matter is quite different. The teacher, however, may do some very definite things looking toward the creation of an atmosphere of interest. Among these the following are most worth while:

(a) The teacher may show her own appreciation quietly, sensibly, and sincerely.

(b) The teacher may admit her deficiency, regretting that she cannot go further, but admire those who do appreciate far beyond her ability to do so. She thus shows her recognition of the value of the subject-matter and creates in the child the desire to appreciate with those who appreciate most.

(c) The teacher should lead the child to grow in appreciation at his (the pupil's) own rate. It is useless and actually detrimental to try to force appreciation. It is an affair of the feelings and cannot be forced.

(2) *Providing Proper Exposure to Appreciation Material.* This the teacher may do in various ways. She may read to children material which

is within their comprehension and which should make an appeal. She can return to this material again and again, giving opportunity for an increased number of children to reach the point of appreciation. She may vary the opportunities by bringing in pupils of superior ability from upper grades to read a poem, present a play, or present a special report. She may take pupils to public libraries or art galleries, calling sympathetic attention to the creations reasonably within their grasp. She may, by contrast in room decorations, painting, or music, create dissatisfaction with the inartistic, and appreciation for that which is more artistic. The point to this step is that it is merely an exposure—an opportunity for the children who are able to grasp it. It should be managed in such a way as not to cause annoyance or dissatisfaction to those who are unable at the time to appreciate that which is presented. Trips to industrial plants or historic sites have appreciation possibilities.

(3) *Giving Appropriate Fundamental Knowledge.* This step should proceed slowly and cautiously under two captions:

(a) Mastery of the technique of poetry, music; painting, et cetera, is not essential for appreciation. In fact, urging the mastery of technique too strenuously or too soon may lead to disgust or other effects directly opposite to that intended. For instance, committing to memory tables of measures should be discontinued.

Many upper-grade pupils who had to parse large sections of Milton's "Paradise Lost" formed a permanent dislike for that great poem; while other pupils, who were led by better methods into the beauty and comprehensiveness of Milton's ideas, have been able to gain from it a permanent viewpoint and source of pleasure. A group of senior high school boys, in comparing notes and chatting about their high school work, agreed unanimously that the best thing they had had in their four-year high school course was the study of Milton's "Paradise Lost" with a teacher who knew how to teach it.

(b) Properly handled, a small amount of analysis of appreciation material will, for most pupils, increase the degree of enjoyment.

This analysis of *fundamental reasons* will form a basis for criticism. It permits the child to judge between that which is good and that which is not so good. There is in this step, however, a great danger that the teacher may permit the underlying reasons or the philosophy or the detailed analysis to become an object in itself. In this manner, the true purpose of appreciation subject-matter is missed and the result may be to turn the child away with a feeling of disgust. The right procedure here is to keep well behind the child's interest. Present an idea; if there is no response, do not go further. If possible lead the child to raise the questions which should be answered along the line of fundamental reasons. When the adolescent period is reached, the child is keener for reasons and may be expected to go more fully into them with the result that appreciation is further increased through them.

The two items under this third step in the appreciation technique are chiefly negative. For the ordinary child, the effort should not be placed on the mastery of technique, nor on the comprehension of fundamental rea-

sons, nor on the committing to memory of facts. An attitude which is too intellectual is almost sure to destroy the desired emotional effects.

(4) *Providing for Expression and Growth.* If the child has become interested, if he has been exposed to appreciation material, and if he has been taught according to his ability to comprehend some of the simple, fundamental knowledge on which to base appreciation, then he is prepared for the fourth step, which is a reasonable expression of himself either with reference to the appreciation material or in the appreciation material. This he can do by:

(a) Choosing
(b) Repeating
(c) Attempting to execute or create
(d) Working in a group or a club.

The mere act of *choosing* the best among several songs, pictures or poems leads the child to put himself, more or less, into the choice. For example, a third grade undertook to pick out the three best poems of Robert Louis Stevenson, and in trying to do so canvassed a very wide range of possible choices. Different pupils chose different poems, and finally the teacher did not require the entire class to agree. Some of the favorites which were advocated strongly by different members of the class, they desired to memorize in order to have them as permanent possessions or to recite to their parents or smaller brothers or sisters at home. In this step of choosing the teacher should be careful not to impose her likes or dislikes upon the class. The child should be led to choose freely and to have his own reasons for choice even though the teacher has not the same choice. Appreciation is largely a personal matter, and depends somewhat upon the experiences and interests of the individual.

Repetition of enjoyable material adds to the enjoyment. When a child has found something which he really enjoys, he should be given the opportunity of returning to it again and again. Children like to be given the opportunity to select their favorite songs or favorite poems or favorite stories. There are some stories which lower-grade children call for again and again. They do not tire of them. Their appreciation is increased by repetition. The same is true of appreciation units in any field.

The *attempt to execute* a song or create a poem, properly handled, will appeal to children and will give satisfying results. Thus a group of second grade children in the Horace Mann School, averaging seven years of age, undertook to writes poems about spring. Everyone in the class wrote such a poem with more or less success. The following are two of these:

Spring

The sun is bright; the sky is blue,
The robin sings his song to you,
The children dance and scamper and sing
To see that once more it is spring.

Spring

'Tis spring! 'Tis spring!
The cheery robins sing,
The flowers awake from their long winter sleep.
In the brooks in the meadows the little fish leap.

Preceding this work a poem about spring had been studied and the pupils had looked through the works of various authors in trying to find further

poems relating to spring. It was surprising to see how far these children went when given this opportunity for choice and expression. The purpose, however, in asking all children to write a piece of music or a poem, is not to make all of them composers or poets, but merely to have them do enough so that their appreciation will be increased. To understand the simple question and answer of music adds much to the enjoyment of simple songs. To write successfully a little poem which has the proper beat and the proper rhyme helps in appreciating the difficulties involved, as well as the harmony and beauty in successful poems. Likewise, digging into sources for the story of the historical development of the foot measure had an appreciation appeal for one bright sixth grader.

Organizing into an appropriate *appreciation group or club* increases the interest and builds up enthusiasm. These clubs need not be permanent, but children enjoy an art club, and this may encourage those who do well to go further. Likewise, in a music club, the children may take an interest in music according to ability, and of course may use mechanical means of expression such as the player-piano or the phonograph. The mathematics club now has a place in many school rooms. The idea in the group organization, however, is not creation but merely increased appreciation.

Building up Appreciation. Appreciation can be cultivated. It results naturally through the application of the laws of readiness, association, exercise and effect. The law of readiness suggests the uselessness of trying to take the child beyond his depth. By using, however, the behavior patterns which are already marked out and the potential capacities which are already developed, the child can be helped to appreciate simple beauty and harmony in nature and art. Through the laws of exercise and effect the field of appreciation can be gradually broadened, but the skillful teacher will not try to hasten the process beyond the power of the child. The field must broaden very slowly and always find substantial basis for new experience in previous pleasurable experience. With increased maturity and broadened interests, through the operation of the laws of association, the appreciative ability of the individual may be as broad as life itself, but this is a goal seldom attained. The effort should be rather to make sure that every pupil has an appreciation of one or two worth while lines, which will afford real enjoyment and recreation during leisure.

In an attempt to build up appreciation, it must be remembered that it is largely a personal matter and depends so much upon previous experience, association and interest, that individual choice and preference must be given consideration. A poem which suggests a dear friend or a delightful trip to one person may suggest death or some unpleasant experience to another. No attempts should be made to force the opinion or preference of another. There is no doubt, however, that the teacher will be able to build up appreciation on the part of her children and to give them in this way a permanent inheritence of feeling and ideals. In her teaching of appreciation subject-matter the teacher will do well to observe the four steps developed under the technique of appreciation. Proceeding thus, she may be assured of favorable results.

Appreciation Opportunities in Elementary Mathematics. It is only recently that teachers have been willing to apply a major technique other than drill to any phase of mathematics. Yet it is well known that some people do develop permanent interests in this field. It can become a lifelong hobby, a recreational opportunity, a source of enjoyment.

All phases of higher mathematics are essentially appreciation, except for the engineering student. In the grades there are such appreciation opportunities as the ciphering match, the story of a unit of measure, measures applied to a commodity, an algebra unit, a simple geometry unit, number puzzles and games. Any number process beyond common usage, such as proportion or square root or compound interest, should be taught as an appreciation unit, not as drill.[2]

Poetry is used as the basis of thinking in most of this article because for the general reader it should be one hundred per cent appreciation. Few people attempt to write poetry; they merely read it for enjoyment. More people try to execute in music and painting, but when it comes to mathematics, the number of those who pursue it for pure enjoyment is very, very small.

And yet, mathematics has many real appreciation opportunities. It is the one field in which a rule can be established by a single example. In this field of number, perfect scores are possible; exactness is possible; "ifs" and "ands" have no place. At the same time, number affords the best check in many inexact and intangible situations. For instance, the business man learns to reduce his estimate to a figure in order to make comparison with another possibility.

In arithmetic, any process beyond the fundamentals, simple fractions, and a reading knowledge of decimals, should be taught as appreciation material. Measures and denominate numbers are reference material for understanding in general, and then for pursuit according to pupil interests and choice.

A bright sixth grade pupil who studied the historical development and persistence of the foot measure, got an enthusiastic response from his classmates when he made his report to the group. "The foot has remained essentially unchanged throughout the centuries—Greece, Rome, Central Europe, England, America. It is the convenient small measure for construction, exactly as the yard is the persistent and universal measure for cloth. The meter or metric yard survives because it is a close approximation to the customary yard."

"Then you don't think the king's foot and arm had much to do with the English foot and yard," remarks another bright pupil.

"Nothing! That is unjustified simplification to make it easy for small children. But it is unfair; it is not the truth."

Cobb[3] developed a unit on paper bags with a fourth grade class. A paper bag is a rough measuring unit. The markings on a paper bag tell a story. There are sizes and types. The study led to a collection, an exhibit,

2 See Chapter XXVIII of *Teaching the New Arithmetic, op. cit.*
3 Cobb, Florence E., "The Story of Paper Bags," *Education,* 65:485-487, April, 1945.

much interesting study, and correspondence with a large manufacturer of paper bags.

Any measuring unit has equal opportunities.

Or measures may be studied from the standpoint of commodities. Any commodity has its favorite unit of measure—gasolene, butter, corn, wheat, hides, leather, shoes. The story of shoe sizes is a very interesting one, and carries the investigator easily from the house to house cobbler of colonial days to the shoe lasts and modern shoe machinery of today.

The tables of weights and measures are for reference only. Committing to memory of the tables is a waste of time. To the man who knows his job or the commodity he is buying or selling, the unit of measure is important, to be sure; but from the standpoint of memory, a mere incident.

Any worth while phase of measures can be better taught through the appreciation approach.

BOOK REVIEWS

Readiness for School Beginners. By Gertrude H. Hildreth. Yonkers-on-Hudson, New York. World Book Company. 1950. xviii and 382 pages. $3.60.

Research findings indicate that a child should have a mental age of six years and six months before attempting to learn reading, arithmetic, and other academic skills. From 30 to 40 per cent of the children entering first grade are under this mental age and are, therefore, not ready for traditional first grade learnings. If these children are plunged into a formal program, in which learning to read is considered their major task, they are likely to become discouraged, anxious, and insecure. Because of their initial discouragement many of them will make little progress in learning to read throughout the first year. Indeed, the expectation of school failure may become permanent, so that they may never gain enough self-confidence to do well in school.

"The chief limitations of traditional schooling are," writes Dr. Hildreth, "first, the failure to provide an adjustment period and to teach pupils the new skill of going to school; second, the repressive atmosphere which stands in such marked contrast to the child's home life; third, the academic curriculum, which hurries little children into book-learning before they can do this learning easily and before they have acquired other more fundamental adjustments and skills; and fourth, the tendency to overlook individual differences in ability and background among the pupils, and the failure to take account of individual needs."

The modern curriculum for school beginners is aimed at the child's all-round development, particularly his emotional and social development. The program is planned to help him become oriented to the school environment, to make desirable social adjustments to the other children, to improve in using oral language, to care for his personal belongings, to learn personal hygiene, and to learn to take part in a variety of classroom and playground activities. Such a program not only contributes greatly to the child's adjustments as a person but also helps him become ready to learn the three R's. This is the theme of *Readiness for School Beginners.* The book is well written and well organized. It is full of practical suggestions for conducting a modern first grade. It should be read by every first-grade teacher and by those responsible for planning and administering a first grade program. — Ruth Wood Gavian, Assistant Professor of Education, Brooklyn College.

Our Meteorological Detective Story —Tomorrow's Weather

By E. B. RIDEOUT

Meteorologist, Station WEEI, Boston, Massachusetts

Editor's Note: Teachers of mathematics will find the material presented so fascinatingly in this article, an excellent springboard from which to suggest an appreciation unit in the field of measurement.

ONE of the most interesting aspects of our planet's weather pattern lies in its geneological origin. Actually we owe our weather conditions to a celestial phenomenon occurring at the beginning of the Earth's history. Something—perhaps a random collision with a hit and run meteor—jarred the planet Earth sufficiently to tilt its axis an exact 23½ degrees. Had the Earth's axis remained on an even keel, we might assume that none of the variety of weather phenomena now a part of our daily existence would ever have taken place. It is interesting to speculate on what the weather might have been like had the Earth's axis not been affected: Year in, year out, the weather all over the Earth would be the same; there would be no seasons, since there would be no variance in the sun's declination; there would be no difference in the length of the days from one year's end to the other. Like the victim of a concussion, old mother Earth has followed an erratic and unpredictable but nonetheless fascinating—climatic course ever since she received the original blow.

We can, however, be thankful that it happened. To a great extent, mankind's material progress, his ingenuity, and his adaptibility stems from his age-old struggle against the extremes and rigors of climate. This is why weather is always paramount. It is why "the weather" is always a lively topic of interest and conversation. It is axiomatic in journalism that "weather is news;" hence, in ordinary times the day's weather rates a front page box; and when it goes on a rampage, it occupies the entire front page.

From the very beginning of recorded history, man has not only carefully tabulated weather happenings, but also, as time has gone on, he has developed instruments for recording its occurrences. As we trace this pattern of development, in conjunction with the painstaking search for information and appraisal of data that typifies today's weather forecasting, we glimpse a phase of detective work that has been going on since man first felt the need to anticipate climatic changes for self-survival.

Historically, man first began to measure the condition of the air and to record his observations for historical and comparative purposes about 300 years ago. Such measurements necessarily awaited the invention of their two primary recording instruments—the thermometer and the bar-

ometer. Both of these instruments, in the first instance, depended upon mercury for recording their data. The first thermometer was made by Galileo around 1590, and the mercury barometer was invented by Torricelli in 1643.

As soon as these two instruments achieved scientific acceptance, the first observations were made and recorded. The next logical step in the process was the assembling of comparative data which became the earliest reference material in weather history. Obviously this recording of early weather history on the European continent was somewhat haphazard at first, but during the past 150 years, both in Europe and in this country, the records have been kept with considerable accuracy.

One of this country's earliest and most renowned meteorological detectives was Benjamin Franklin. Not only did he accurately deduct that lightning is unharnessed electricity, but also he established that Northeast storms come from the Southwest in the majority of instances. This came as an outgrowth of his discovery that all storms move in a general Westerly to Easterly direction in a circulatory motion.

Despite the scientific predictability of certain weather phenomena as demonstrated by Franklin, the lay public for many years was convinced that weather was a completely unpredicable and irrational force. It was not until the invention of the telegraph, with the opportunity it afforded to compare a variety of observations almost simultaneously, that meteorology began to develop, in public understanding, as a precise science following a set of well defined laws. Since then, meteorology's detectives have been skillfully at work, discovering new clues which in turn lead to the discovery of certain natural laws governing the science of forecasting accurately the trend of tomorrow's weather. As in all basic research, however, there are still gaps in our knowledge. Bluntly stated, when the weatherman is wrong—and it happens to the best of us—it is usually the result of some unforeseen action of the still hidden laws of meteorology.

Today's scientific meteorologist bases his weather predictions upon a carefull analysis of regional weather maps combined with his experienced interpretation of weather instrument readings. Yet instances occur when two similar sets of maps and readings will produce, on different days, two entirely different sets of weather conditions. For instance, we will take a map showing a storm moving Eastward with its center over the Northern Great Lakes Region. In the Southern part of the storm there may be a slight elongation to the Southward into the Ohio Valley, while in the rear of the storm an extensive cold wave may be coming out of the Canadian Northwest. Based upon this weather map pattern the middle Atlantic slope and New England will experience increasing cloudiness with rising temperatures and rain; even though this may occur during the winter months. Within a week, the same basic weather map, coupled with almost identical readings, will produce a storm over the Middle Atlantic coast, bringing with it snow and falling temperatures.

Similarly, there are times when, on the basis of the best available information, a cold wave is forecast for the middle Atlantic States and New England. This forecast may be the result

of an energetic cold wave coming out of the Northwestern Canadian Provinces. Now in one case this may follow the indications very accurately. Then again this cold front may sweep almost directly Southward down over the Mississippi Valley States, into the Central and Eastern Gulf States, and thence off the South Atlantic coastal regions. In such an instance, the cold wave may by-pass New England entirely .

There are other instances, both locally and nationally, in which sudden changes occur that cannot be foreseen, sometimes proving beyond a shadow of doubt that the weatherman can be wrong. Nevertheless great strides in the accuracy of weather forecasting have been made, and will continue to be made. Barring an opportunity to function as a glamorous "private eye," I'll stick to tracking down tomorrow's weather.

BOOK REVIEWS

Our Children and Our Schools. By Lucy Sprague Mitchell. New York. Simon and Schuster. 1950. xxviii and 510 pages. $4.00.

Mrs. Mitchell brings to her latest book a wealth of experience as a teacher and adviser in some fourteen experimental schools over a period of thirty-four years. The volume deals particularly with the work of Mrs. Mitchell and a workshop group in attempting to adapt the best of modern procedures to a public experimental school, the Bank Street School, in New York City. The result of her efforts is a book which should prove most helpful to teachers, especially in metropolitan areas, seeking ways and means of organizing children's experiences so as to obtain the maximum of growth and development for their charges. Greatest help is given in the field of social studies, where several chapters are devoted to the experiences of the Bank Street School in meeting the needs of boys and girls at various stages in their elementary school careers. The volume is divided into four parts: Part I, What Our Schools Are Leaving: Moving Toward; Part II, Our Public Schools in Action: Stages of Workshop Growth; Part III, Broad Learnings and Implications of Workshop Experience; Part IV, What Next? A seventy-five page appendix contains numerous fragmentary accounts of experiences from workshops and classes at Bank Street. Many of these are most helpful.

Most readers will wish that the few good pictures found on the book's flyleaf might be supplemented by many more throughout the work. Others would appreciate the help of an index, which is not included. Those wishing help in supplying number experiences and developing arithmetic skills will find almost no help. Despite these shortcomings, Mrs. Mitchell's work will fill a need of those wishing to profit from the experiences of a sincere group striving to apply to a group of city children the best of what is known about modern elementary education. — W. H. SAUVAIN, Professor of Education, Bucknell University.

The Measurement *of* Time

By ELISABETH ACHELIS
President, The World Calendar Association, Inc.,
New York, New York

Editor's Note: This new approach to an appreciation unit about the calendar will intrigue both teachers and pupils.

SOMEWHERE in every school program there should be a place for basic instruction in regard to the calendar. This ought to cover the history of our system of time measurement and its intricate mathematical problems, which man has tried to solve, down through the ages. Two years ago when I had the pleasure of speaking on this subject at the Baltimore Convention of the National Council of Teachers of Mathematics, several hundred delegates agreed that appreciation of the calendar has a distinct place in the background of every mathematician. Time measurement was primitive man's first great intellectual achievement. It went hand in hand with the development of the arts of writing, agriculture, numbering and elementary geometry. Students and teachers should know also of the current international proposal for the revised and improved World Calender.[1]

Ever since man has inhabited the Earth he has been fascinated by the sun, moon and the stars which so faithfully regulate his days and nights. In their orderly recurrences they challenge man. They hold him in their irresistible sway, for he can but study and obey celestial law, and work in harmony with that majestic force, called Time. To adjust himself to Time, after many primitive methods and trials, man established the calendar and arranged it into days, weeks, months and years. It is generally conceded that the solar seasonal calendar was man's first organized achievement.

The 24-hour day, the shortest unit in the calendar, is the time it takes the Earth to complete its rotation on its axis. Then comes the week of seven days, originating from the Babylonians and later adopted by the Jews, who gave to the week the religious interpretation of the seventh-day Sabbath of rest. Later the week became an established calendar-unit through the edict of Constantine, the Great. It is generally believed that the moon with its four phases, each of seven days, was the basis of the week. The seven known planets, which included the sun and moon in ancient days, might also have given rise to the week, a theory further substantiated by the planetary names given the seven days. It is the seven-day week which is the obstinate and difficult member of the calendar family as it cannot be fitted into the calendar year of 365 days. The month was derived from a completed moon cycle. In early days twelve full or new moons comprised

1 Background material for teachers is available on request from The World Calendar Association, Inc., International Building, 630 Fifth Avenue, New York 20, New York.

a year. The seasons, influenced by the sun, are not so clearly designated in the calendar. They are recognized by specific dates, such as March 21, the beginning of Spring, when the sun crosses the meridian on its northward course in the sky—the Vernal Equinox at which point the days and nights are of equal length. Then comes Summer, when the sun reaches the highest point in the heavens—known as the Summer Solstice; Autumn, when the sun recrosses the meridian point on her southward journey—known as the Autumnal Equinox when once again the days and nights are equal in length; and Winter, when the sun reaches the lowest point in the heavens —at the Winter Solstice, after which point the sun once again resumes its northward course. The seasons are natural time-periods denoting the sun's annual course in the sky—immutable laws of nature. The solar seasonal year is composed of the number of days it takes the Earth to complete one revolution around the sun—approximately 365¼ days. This, too, is an inviolable natural law. Man, therefore, arranged the calendar as of 365 days in common years and 366 days in leap years, thereby measuring a single year in the unceasing flow of Time.

There were three distinct types of calendars in use in earliest times. Due to the comparative ease with which man could study and observe the moon, the earliest calendars devised were lunar, of which the present Mohammedan calendar is a notable example. In the moon calendar seasons are ignored. It has 12 months, alternating between 29 and 30 days in length, which causes the lunar years to be short of the seasonal solar year by about 11 days. Therefore, each month of a lunar calendar progresses through the seasons until, after 33 years have passed, it returns to its original place in relation to the seasons.

Another type was that of the luni-solar calendar used by the Jews, who, we are told, inherited it from the Sumerians. This calendar was based on the moon and had 12 lunar months. As it was short 11 days, however, it was adjusted at intervals to the seasonal year by adding an extra or intercalary month about every third year. In this manner the luni-solar calendar kept step with the seasons. The Jewish calendar inserts an extra month at the end of the 3d, 6th, 8th, 11th, 14th, 17th and 19th years within a 19-year cycle.

A third type was that of the solar seasonal calendar, developed and put into actual use by the ancient Eygptians about 4236 B.C. The Egyptians depended for their food on the behavior of the River Nile, whose annual inundation or flood was vital to the agriculturists for fertilizing the land and planting and harvesting the crops. Thus it was that the inundation or flood season became the basis of their calendar. Previous lunar calendars were abolished, and with accumulated wisdom gained through knowledge and experience a *purely solar* calendar was adopted. This marked a decidedly progressive step in the history of the calendar. The year of 365 days was established, and the 12 months, no longer associated with the moon, were each given 30 days. The last five days of the year were observed as festival days.

Many years later, about 300 B.C., the Egyptians discovered that the year was not 365 days but about a quarter-day longer. Ptolemy Euergetes and

his eminent scientist, Eratosthenes, endeavored to correct the calendar by inserting an extra day every four years to take up the slack. This extra day was to be dedicated to the "Good-doing Gods." The Egyptian priests, however, fearful that they might lose their previous prerogative of such insertions, refused to accept this *regular* leap-year day every four years.

To the Romans, under Julius Caesar, belongs the credit for adopting and putting into practice the leap-year day, which the Egyptians had rejected. The Julian calendar further established the solar seasonal calendar inherited from the natives of the Nile. With the aid of the astronomer, Sosigenes, Julius Caesar arranged the calendar on a 12-month basis but the extra five feast-days were distributed throughout the year. All former moon months were discarded and each month became approximately one-twelfth of the year. To effect this reform a long year of 445 days was observed in 46 B.C. The following year, 45 B.C., was the first with the Julian calendar in actual use.

A change in the beginning of the year had been previously made in the Roman calendar. From the 25th and later the 1st of March it became the 1st of January, because on that date the Consuls assumed their civic duties. This political event was so closely associated in the public mind with the first day of the civil calendar that the beginning of the year was separated from its scientific source. So it is that today the year begins with the first day of January—a Roman heritage.

The next notable change in the calendar was the introduction of the seven-day week. Known and used by the Jews, it became a fixed time-unit in the Julian calendar, by an edict of Constantine the Great, first Christian Emperor. He also established Sunday, the first day of the week, as the day of praise and worship in honor of the Resurrection.

For twelve centuries the Julian calendar was the time instrument for the western world until once again it called for adjustment. As previously the Egyptians had discovered that their calendar no longer fitted the seasonal year, so Pope Gregory XIII and his astronomers discovered that the calendar was once again running away from the seasons. The Gregorian Reform was adopted in 1582, whereby only century years divisible by 400 were to be leap years, while the leap year every four years remained. Then to align the calendar once more with the seasonal year, ten days were dropped; Thursday, October 4, was followed by Friday, October 15. The Spring Equinox was established on March 21.

When England and her American colonies accepted this reform about 200 years later Americans observed a strange anomaly. George Washington, born on the 11th of February, was obliged to change his birth-date to the 22d of February. In the interim a centurial leap-year day in 1700 had been observed in England, causing 11 days to be dropped instead of the original ten.

Thus we see that the calendar is man-made. There is nothing sacred or immutable in the calendar as such, provided it conforms to certain scientific laws—a day of about 24 hours and the seasonal solar year of approximately 365¼ days. Now again a revision of the calendar is needed. Scientifically it is as accurate as man could wish, but for practical and economic

purposes the shifting calendar every year (beginning each year on a different day of the week that causes changing days and dates) is a hardship which calls for improvement.

Of the proposals submitted to the former League of Nations and the many submitted to the United Nations, one calendar plan, The World Calendar, looms above them all. It is a perpetual civil calendar of 12 months, equally divided into quarters of three months, with days and dates always in agreement. Thus there is perfect coordination among the various time-units, comparisons are easily made, and an equitable balance is attained. In the words of Robert Bridges: "Our stability is but balance." Planning, calculations and computations are simple. The three months have their fixed number of days—31, 30, 30—and all have exactly 26 week days plus Sundays. To complete the year, the 365th day is added to the outgoing year following Saturday, December 30. It is called Worldsday, inserted between two weeks and dated December W, a world holiday that may well be dedicated annually to greater world unity, cooperation, and understanding. The 366th day in leap years is added to the end of the second quarter as Leapyear Day, dated June W, another world holiday or festal day. This inspired idea of the one or two "stabilizing" days was the concept of a Roman Catholic priest, Abee Marco Mastrofini. He found the solution of the problem which had been the Gordian knot for untold centuries. The World Calendar has been scientifically certified as "the most exact system of time measurement that can be attained without serious dislocation or disturbance." Mathematically speaking, it is well-nigh perfect.

Certainly the time has come to anticipate this much-needed revision. In these days of tension and crises, the saving of valuable time, effort, material, and money that this calendar will make possible, cannot be lightly disregarded. This valuable contribution to world order and world unity cannot be had on its own initiative. Like all good things, it must be worked for and earned. The time for adoption is Sunday, January 1, 1956, when both the Gregorian and The World Calendar coincide as to day and date. This new year of 1951 marks the year of work and action so that international approval by the United Nations can be had not later than January 1, 1952. Then the intervening three years are the preparatory years for its adoption Sunday, January 1, 1956.

A paraphrase from Hamlet is pertinent—

Our Time *is* out of joint, but oh delight,
That we are born *this day* to set it right!

The Thousandth *of an* Inch *in* Industry

By FRED H. COLVIN
Editor Emeritus, American Machinist

Editor's Note: This article provides in capsule form background material for a stimulating appreciation unit in mathematics.

JUST as machine tools are the master tools of industry and the basis for modern manufacturing, so accurate measurements are the foundation of the modern machine building industry. Accurate measurement, symbolized by the machinists micrometer, standard gages, and the measuring block, distinguish modern manufacturing from the making of parts which have to be fitted together in assembly and which cannot be replaced except by a similar fitting process.

The more we have refined our methods of measurement the more we realize that *exact* duplication of parts is more a dream than a reality, even if we disregard costs. Hundredths of an inch spelled accuracy when I was an apprentice. Then "thousanths" became standard practice. Now "tenths" are just as common and micro-inches, or millionths of an inch, are measured with optical flats and light-wave equipment.

In spite, however, of almost unbelievable advances in the accuracy of our machine tool equipment for boring, turning, milling and grinding, we still have to warn young designers against specifying "tenths" in dimensions where thousandths and even hundredths will be perfectly satisfactory in practice. For even with the best of equipment and care, small deviations from exact basic dimensions are bound to occur and can in most cases be tolerated without materially affecting the operation of the mechanism being built.

Some old-time mechanics, using only plain, firm-joint calipers, worked to much closer limits than they realized or than now seems possible, depending on the sense of touch or "feel." I have known old railroad shop mechanics to bore locomotive driving wheel hubs to fit previously turned axles, and to predict very closely the pressure that would be required to force them in place. Probably no two of them were as nearly alike as similar fits today, thanks to better machining methods and also to better measuring devices.

Eli Whitney has been called the father of interchangeable manufacturing. While he deserves great credit for his work it is doubtful if it would be considered interchangeable by modern standards. I doubt if he had reached the stage where specified "tolerances"[1] were recognized as necessary for interchangeability. For as late as 1916 one large arsenal had no tolerances set for rifle parts except for the thickness of the bayonet blade.

1 Fractional allowance for variation from standard.

This was held to 0.002 inch when the only tolerance necessary was that it go in the scabbard.

Henry Leland, head of Cadillac Motors for many years and later the founder of the Lincoln Motor Company, was a pioneer in really accurate interchangeability of motor car parts. It may be recalled that he sent three Cadillacs to a London Automobile Show, had the engines torn down and then reassembled without regard to the parts which originally went together. The parts were remarkably accurate for that time. This could probably be duplicated today by a number of builders, except for the pistons and piston pins. For the industry has found it better to select these parts with regard to cylinder bores, piston pins and the holes into which they fit, largely because of the expansion due to the heat of a running engine.

Probably the greatest accuracy ever attempted in this field, and for the most part secured, was in the Wills-St. Claire car. Here C. Harold Wills, for many years responsible for the successful manufacture of the Ford, attempted to maintain greater interchangeability of all vital parts than had ever been attained. He built engines whose parts were remarkably interchangeable, but at a cost that proved prohibitive in competition with the rest of the industry. This is the reason that it is well for designers to consider selective assembly for parts subject to wear. As replacements must be oversize, it is now customary to have several "over-size" standards from which the best is selected for each case.

Then, too, it is most practicable in many cases to confine real interchangeability to a unit or subassembly rather than to strive for interchangeability of each component part. On automobiles, for example, we expect carburettors, oil and fuel pumps to interchange as units but do not look for complete interchangeability of individual parts. This does not mean that the parts are not accurately made. It merely emphasizes the fact that better fits can be secured, at lower costs, by using parts that have been previously graded to very close limits. Parts subject to wear could not be replaced satisfactorily by spares made to one standard dimension.

Some years ago a well known firm rejected a lot of armature shafts made by another equally well-known firm, as being too small. A conference disclosed that the reason for rejection was due to the difference in the technique employed by the two concerns. In the purchaser's shop it was the practice to use pressure in checking the diameter with a snap gage. The practice of the supplying shop was to consider a shaft correct when the snap gage would slide over the shaft by its own weight. The difference in the shaft diameters due to this difference was easily measured and specifications drawn up to insure similar measuring practice in both places.

In order to avoid this element of "feel," as mentioned in the case of the locomotive axles and wheel hubs, standard measuring pressures are being adopted for gaging screw threads and will probably be developed for other products as well. Without uniform practices the extreme accuracy of some devices is nullified. As an example, the Van Keuren wires used in measuring screw threads are now guaranteed to be correct as to diameter within 25 millionths of basic size. Standard

pressures have been adopted for measuring 60 degree, and Acme and worm 29 degree threads. For threads finer than 20 per inch the standard pressure is one pound while for coarser threads 2½ pounds is the standard pressure.

Temperature is also an important factor in accurate measuring. This may come either from atmospheric conditions or from handling of the work. With air-conditioned inspection rooms at 68 degrees Fahrenheit only handling is likely to be a factor, but these should be carefully noted.

Confusion sometimes exists as to the use of gages. They do not really measure work but merely show whether it is within the desired limits, or near enough to basic size to be satisfactory in use. Misunderstandings also occur regarding tolerances, much depending on whether the bi-lateral or uni-lateral system is used. Unless this is known one does not know whether the whole tolerance is meant or only a plus or minus tolerance. Users of the bi-lateral frequently give only one tolerance, which can be misunderstood to mean *to* total tolerance.

With a plug above basic and a hole below basic, but within the tolerance there would be interference and selective assembly necessary. With uni-lateral tolerance all dimensions of holes are basic plus the tolerance, and all shafts basic minus the tolerance.

In closing let me repeat the warning against tolerances which are unnecessarily small. It is much better to have work come within a reasonable tolerance than to have costly rejections because smaller tolerances have been named than are really necessary in actual practice.

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Weights *and* Measures *in* South America

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THE story of weights and measures in South America is a fascinating one, and typical of that to be found in any part of the world where compulsory metric usage has been attempted. When the Spanish Conquistadores and Portuguese explorers in the sixteenth century settled the rich New World, they brought, along with their language and customs, their customary[1] weights and measures. It was not until the 60's, 70's, and 80's of the last century that laws were passed making the use of the metric system[2] compulsory, enforced by means of substantial fines or imprisonment, or both. If our good neighbors to the south had made a thoughtful study of the problem at that time, instead of succumbing to metric propaganda,[3] it would have been possible with some slight changes to have adjusted the customary Spanish and Portuguese measures to the English, and so they would have secured for themselves the advantages of uniformity with the two greatest industrial and commercial nations in the world today—Britain and the United States. Probably the importance of such uniformity was lost sight of, however, because in 1862 South America was little developed industrially.

The writer undertook a field study[4] in Brazil, Argentina, Uruaguay, and Paraguay to discover: (1) what customary weights and measures, if any, are used in the trade and industry of these four east coast countries, where the use of metric units is compulsory; (2) to what extent, in general, customary units are used, if at all; and (3) what effects the compulsory use of metric units may have. The findings were illuminating. In the interior the use of metric units are generally disregarded, since the compulsory laws are not so strictly enforced in the hinterlands. The following are typical findings. In Paraguay which is in the interior, a thousand miles up the Plata and Paraná Rivers, the people use metric weights and measures very little in actual bargaining even though they may use metric terminology. Furthermore, most of the domestic trade is carried on by barter. The people, if they have any

1 Those weights and measures which through the centuries have survived on the basis of usage rather than fiat.

2 The forty-five (not including the franc) weights and measures of the original metric system (1792) and logical extensions of the same.

3 Wilson, Guy M., "Metric Promises and Shortcomings," *Education*, 69:641-647, June, 1949.

4 Yorke, Gertrude C., *Some Effects of the Compulsory Use of Metric Weights and Measures in Brazil, Argentina, Uruguay, and Paraguay*, Unpublished Doctorate Dissertation, Boston University, 1942.

money, are so poor in general that they buy in very small quantities. The head of one of the largest cotton firms in Paraguay summed up the situation by saying that even though the country has nominally adopted compulsory metric usage there has been little change really in the use of weights and measures. He said that the men he does business with still think and talk in arrobas (25.35 pounds).[5] Thus if the price of cotton is quoted at 15.50 pesos per kilo, the Paraguayan planter quickly multiplies by 10 (an arroba is approximately 10 kilos) and gets 155 pesos per arroba. He can then judge whether or not the offer is a good one. En route to Buenos Aires, a traveler[6] whom the writer met on the S. S. General Alvear, reported that he had seen in the interior of Paraguay arrobas used for measuring shelled corn (60 ears of corn to an arroba). He had also found that mano (handful) was commonly used as a measure; that thatching grass was sold by the vardo (bundle); and treacle[7] by the cattle-hide-full. In this connection a letter from Dr. Weiss, who has lived for many years in the interior of Paraguay, gives the following information, "As to Paraguay there are still many old weights and measures used in the country such as the almuda (1/3 bushel) which is used for salt and grains. The Guarani, Caingua, Guayaquies, and Chaco Indians use primitive units such as: a man's weight, a child's weight, or a day's journey." In regard to the Argentine, Dr. Weiss writes: "There are still some very old weights in use for hides and sheepskins, such as una pesada. For dry hides a pesada is 35.45 pounds, for salted hides 60.77 pounds, and for washed sheepskins 30.38 pounds. There are many other customary weights and measures still widely used such as, cuarta (1.05 pint), frasco (0.54 gallon), galón (6.69 pints), baril (20.08 gallons), and so forth, for liquids; and cuartilla (7.55 gallons), fanega (3.77 bushels), and so forth, for dry capacity."

Along the Amazon River the writer found that the two commodities which are sold in quantity, sugar and wood, are weighed and measured by customary units—sugar by the arroba (32.47 pounds)[8] and wood by the palmo (8.66 inches). The sugar is shipped in baskets weighing two arrobas (approximately 65 pounds) and the wood, which is used by the river boat, is cut into lengths of four palmos (approximately 35 inches). Nuts, also, are sold by the arroba and by the quintal[9] (129.88 pounds); while rice, corn, fish, and tobacco are sold by the former unit, too. At Santarém, a large town five hundred miles up the river, oranges are sold by the arroba, the quintal, and the duzia (dozen).

The situation in the cities, however, is quite different. Stricter inspection and enforcement of the law, involving penalties of fines or imprisonment, or both, cause people to devise methods of evasion. For instance, in Uruguay, where the enforcement of metric usage is stricter than in any of the other South American countries visited by the writer, one of the owners of a

9 There are 4 arrobas in a quintal.
8 A bushel of oats weighs 32 pounds.
5 Spanish.
6 Mr. Alan D. Menmuir.
7 Molasses.

large importing concern in Montevideo explained that, in order to comply with government regulations which impose a fine if any weights and measures except metric appear in catalogues or newspapers, his company assigns approximate metric units to imported goods. Thus in their catalogue a package of Post Toasties is listed as weighing 330 gramos (11.65 ounces); a can of Towle's Log Cabin Maple Syrup 1.1 kilo (2.43 pounds). The writer was shown a bottle of United States Gin, which had the words "one quart" pressed in the glass, but which is called a litra (1.057 quart) botella to evade the metric law. Another method of evasion was explained to the writer by the manager of a large general importing company. This firm sells Fairbanks-Morse windmills by number, but the customer understands that these numbers refer to the height in feet. Thus a number 16 "molino" is a sixteen-foot windmill. The same subterfuge is used for screw threads, a number 16 meaning sixteen threads to an inch, the diameter being given in parts of an inch also as, for instance, ¼ or ⅛.

In the cities, too, the writer found many instances of disregard, as well as evasion of the metric laws. For example, in Buenos Aires a large shoe manufacturing establishment uses English and metric units and local Argentine numbers. The writer was shown a scale on which there are four full sizes to an inch and two half sizes to a centimeter. This same factory buys hides by the foot. The writer also visited the Sociedad Anonima Fabrica Argentina De Alpargatas, large manufacturers of textiles, rope, and canvas shoes. The manager stated that cotton, 95% of which is grown in the Argentine, is bought by this company by the fardo (a bale, which varies in weight around 220 kilos,[10] approximately the same as the bale of cotton used in the United States).[11] A visit to the Sociedad Industrial Americana De Maquineria, an Argentine firm which manufactures machinery for bakeries and service stations (underground tanks and gas pumps), refrigerators, water pumps, filters, and so forth, brought to light that sheet metal is bought in the Buenos Aires market more in inches and fractions of an inch than in metric units. This concern, also, uses British and United States threads.

The London and Paris Department Store, the largest in Montevideo, Uruguay, the writer found, sells gloves, which are made in that city, by numbers 6 to 7¾, and men's and women's hosiery are marked with the same numbers as are used in the United States (8½ to 10, and so forth).

In São Paulo the writer saw displayed for sale in a window of Mappin's Department Store, one of the largest in Brazil, a balanza de familia (household weighing machine), manufactured by Landers, Frary, and Clark Company of New Britain, Connecticut, U. S. A. This machine records the weight in both Portuguese libras (pounds) and onzas (ounces), and metric kilos and grammos, which indicates that customary units are still used by housewives in Brazil. The United States Vice Consul in Santos reported that sugar is sold there by the arroba (32.47 pounds) and half arro-

10 220 kilos (485 pounds).
11 480-500 pounds.

ba. In the city of Manaos, a thousand miles up the Amazon River, the writer found that wood for fuel is measured by the pé (12.99 inches); iron by the pé and pollegada (1.08 inch); rope by the braça (7.16 feet); silver by the oitava (56.68 grains); gold and precious stones by the quilate (3.07 grains); gasoline by the pipa (111.8 gallons); and paper by the reama (500 sheets for printing, 400 sheets for stationery). At the Casa Crocodilo in Belém, when the writer inquired the length of some snake and alligator skin belts, the clerk produced a tape-measure, on one side of which the units were centimetros and on the other pollegadas (inches). In another leather shop in the same city the writer again asked the length of belts, and the proprietor gave it in pollegadas, using a pollegada tape-measure.

Visits to markets afforded an opportunity of getting acquainted with the people as well as of observing the weights and measures, which they actually use in their everyday business transactions. The first one which the writer visited, was the Mercado Publico at Manáos. It was necessary to go with a native guide, who could speak any of the dialects, which are common in the interior, because at dawn the cabôclos[12] paddle up to the shore in their dugouts or canoes which are filled with oranges, bananas, fish, or anything else they may have to sell. Little or no weighing takes place. At this time the wholesale buying goes on, the bidder offering a price for whatever he wants by the lot, usually buying all that a cabôclo has of one commodity. Oranges are sold by the hundred or half hundred. Soon after six o'clock the open-air trading was finished, and the cabôclos paddled away. The writer then visited the large indoor market. Here meat, beans, and rice are sold by the kilo or by the more convenient half kilo (approximately 1 pound), while coffee is sold in 200 grammo (approximately ¼ pound) packages. Farinha, however, is sold by the alqueire (1.03 bushel), and tobacco by the molha (large bundle), but as has been pointed out previously much is sold without using any weights and measures, an effective means of disregarding the governmental regulations in regard to compulsory metric usage. For instance, fish are sold by the string of four or five or by the piece (one whole fish or a half fish); vegetables by the bunch; tomatoes four or five for 100 réis (½ cent in United States currency); and eggs three to five for a milréis (5 cents); yams by the piece; turtles by the piece or quarter; pumpkin by the slice; African oil by the bottle; and tucupy (cooking oil) by the can. The writer stopped at various stalls and recorded in a notebook what commodities were being sold by metric units; what by customary, and what without being weighed or measured. It was frequently necessary for the guide to make explanations to the market people in order to allay their suspicions since they naturally fear government inspection and penalties for not using metric weights and measures.

The writer visited several other Brazilian markets: the open-air and indoor markets in Belém, the equatorial port at the mouth of the Amazon River; the Mercado Modelo in São Salvador, Bahia; the Santos market;

12 A racial type resulting from the mixture for more than three centuries of Indians, whites, and in lesser numbers, Negroes.

and the Mercado Municipal in São Paulo, the latter being one of the largest markets in South America. The findings were much the same in each instance, except that as the governmental inspection and control became stricter nearer the Federal District, fewer customary weights and measures were used, openly at least. In the São Paulo Mercado Municipal the writer found that cheese is sold by the jaca, a basket about a yard in length, containing from 14 to 16 cheeses; sugar by the arroba (32.47 pounds); bananas by the cacho (bunch of approximately 9 dozen); palmita (palm hearts) and eggs by the duzia (dozen); oranges by the case of 100; apples, pears, and cherries by the cada (piece); farinha by 5 kilo (11.05 pounds) bags, 15 bags in a case; coffee in 60 kilo (132.6 pounds) sacks; strawberries by the kilo; and grapes by the kilo and ½ kilo. Tomatoes are brought in to the market from the farms in cases weighing 28 kilos (61.6 pounds) while vegetables are brought from the truck gardens in 10 arroba (324.7 pounds) baskets.

In the public market at Asunción, Paraguay, as has been mentioned above, the writer saw little actual weighing and measuring. This is accounted for by the fact that the great majority of the people have little money and so either barter or buy in very small quantities, bargaining for a certain amount at a certain price. The compulsory metric law has in reality brought about little change here. Thus the writer found that corn, potatoes, fruit, and truck garden products are bought and sold by the old native measure, the arroba (25.35 pounds); honey by the azumbro (0.53 gallon); eggs and fruit by the docena (dozen). Meat is sold by the kilo, ½, ¼, ⅛, and 1/16 kilo, and maté[13] by the kilo, ½ kilo or 100 gram (¼ pound) bag.

The next two markets visited were the large Abasto market in Buenos Aires, Argentina, and the Central market in Montevideo, Uruguay. As might be expected metric units predominated, but the duodecimal docena (dozen) and binary fractions of the metric weights and measures are as commonly used in these markets as everywhere else in South America.

Customary units were also found in use to a considerable extent for measuring land in the countries investigated by the writer. People in all countries where metric usage is compulsory have been unwilling to give up their convenient customary land measures, with which they are familiar, and to use in place of these the inconvenient "are" (118.6 square yards) or "hectare" (2.47 acres). In Brazil the alqueire Paulista (6 acres) is used in buying and selling cattle-breeding property. It is important to the Brazilian rancher to be able to visualize how many cattle can feed on an alqueire. An advertisement in the newspaper, "O Estado De São Paulo," read as follows: "Purchase a breeding farm, located on the São Paulo Central line, of 300 to 400 alqueires (1800 to 2400 acres) more or less." At Santos the United States Vice Consul also reported the use of the alqueire Paulista in the interior.

In Argentina the vara (2.84 feet) and the square vara (8.07 square feet) are commonly used for measuring land. The "Buenos Aires Herald," the leading newspaper of that city,

13 South American tea.

offered a number of examples of this. For instance, one advertisement read: "Quinta house in Olivos, J. Ingenieros 1695, very comfortable, garage, ground 43 x 60 vs. (varas) for sale with facilities." Another was as follows: "In Villa Ballester 10,000 sq. vs. (80,700 square feet) of ground to be sold with shade and fruit trees, in one lot or divided into fractions. Situated," and so forth. Needless to say metric measures are used also.

All large estates in Paraguay, timber land, cattle-ranches, maté, or quebracho[14] properties are sold by the legua or league (3.11 miles), a secretary at the United States Consulate reported. Legua is used, too, in speaking of distance. Deeds of land here, also, mention customary units as well as metric. The old deeds, of course, give all measurements in Spanish units, whereas the new deeds use both customary and metric measures. For instance, a "Transfer of Property," pertaining to lots of land in the capital city of Asunción, contained the following description: "Its frontage on Calle Tercera, now Calle Dr. Manuel Pérez, on the west measures 22 pies (feet) with 4 pulgadas (inches), 30 centivaras, or 7 meters, 188 millimeters,"[15] and so forth. In Paraguay no property can be transferred unless all the documents, including the original deed, are produced, thus providing a complete abstract of title. The file of the above transfer contained 14 official documents, the first of which related to its subdivision from a large property in 1901, and the other 13 to subsequent transfers down to the last one.

In Uruguay old deeds give customary measures: varas (2.84 feet), square varas (8.07 square feet), and so forth; while new ones give only metric measures, if the property has not been sold before and so the document is an original deed. In rural districts, as in Paraguay, estancias (ranches) are bought and sold by the legua or league (3.11 miles) and by the cuadro (94.71 yards or 234.13 feet). The findings in regard to deeds were the same for both Argentina and Brazil.

Lumber, like wood for fuel, mentioned above, the writer found is sold by customary units. For instance, in Paraguay the unit "board meter" designates lumber which is one inch in thickness, one foot in width, and one meter in length. A secretary at the United States Consulate in Buenos Aires, Argentina, reported that lumber there is measured by the pulgada (0.96 inch) and that logs are bought by the 1000 board feet[16] The board foot is used also in Uruguay.

Throughout the countries visited machinery and tools, for the most part, are calibrated to customary units, if they have been manufactured in the United States or England, but to metric units if made in countries having compulsory metric usage. Thus in Sao Salvador, Bahia, Brazil, the writer visited the largest textile mill, that of the Companhia Emporio Industrial Do Norte, which employs 1500 workers. Here the owner stated that most of the machinery in his mill has been imported from the United States and England, and therefore is calibrated to the inch, and measures in

14 Hardwood tropical trees, the bark or wood of which are used in medicines, tanning, dyemaking, et cetera.

15 Pie ((11.13 inches). Pulgada (0.93). Centivara (0.55 inch). Meter (3.28 feet). Millimeter (0.039 inch).

16 A board foot is one foot by one foot by one inch, or 144 cubic inches.

yards, but the folding machines measure in metros, because all the cloth must be sold according to the law by metric units. The two German engines in the mill, of course, have been manufactured to metric measurements. The writer, in Rio de Janeiro, also interviewed the manager of the Cia America Fabrio, which operates a number of cotton mills employing some 5000 workers. The machinery used by this company was imported from the United States and England, and therefore is calibrated and measures to the inch. The manager, however, reported that a new measuring machine for the main mill measures in metric units. In other words this company, one of the largest textile manufacturers in Brazil, is complying with the letter of the law in regard to selling by the metro, but like the mill in Bahia, is otherwise using customary units. Cotton is bought by the bale by this concern. In the factory of the Liceu De Artes E Oficios, a charity industrial school to which 650 boys go in São Paulo, a teacher stated that customary as well as metric units are used throughout the factory, but particularly in the machine shop and for mechanical work. Some of the German machines, which were pointed out to the writer, are equipped with gears in both inches and metric units. Also in São Paulo the writer visited a hardware store, the Confermat S/A, a French company, which sells tools imported from France. The clerk reported that none of these tools is marked in metric units only, but in both inches and centimetros. The steel tapes (100 feet) and foot rules which they sell also have inches on one side and centimetros on the other.

Thus everywhere one goes in the compulsory metric countries of South America, there are two systems of weights and measures: the native customary units and the legal metric units.

In Argentina, a secretary at the United States Consulate in Buenos Aires reported that machinery and tools are calibrated to the inch if they are imported from the United States or England. Customary units, likewise, are used in repair shops, he stated. For instance, if it is necessary to rebore cylinders manufactured in either of these countries, the mechanics have to use inch gauges. Compulsory use of metric units in such a situation just isn't practical. The writer visited the Compañia Argentina De Electricidad (The Argentina Electric Company), and talked with one of the engineers. He stated that in a power station, which was being built at a cost of seven million pesos (approximately $2,000,000), 33 1/3% of the machinery has been bought from the United States; 33 1/3% from England; and 33 1/3% from Germany. Thus 2/3 of this new machinery was manufactured to customary units except that, for the turbines and generators, ordered from the General Electric Company of Schenectady, New York, metric units were specified. He also reported that as the British built the first railways in the Argentine, customary units are used for locomotives, wagons, railway coaches, and bridges. For the same reason sizes of pipe (diameters) for sanitary purposes and water are measured by the inch, although the length is measured by the meter. At the Sociedad Anonima Fabrica Argentina De Alpargatas, where jute-soled canvas shoes are made, the writer found

that they use English machines and United Shoe machinery[17] from the United States, all of which are built according to customary standards. They use, too, some German and Swiss machines, which are built according to metric standards. All their machines which measure leather, do this by metric units. The writer also visited another factory which manufactures the same kind of shoes and cotton goods in Uruguay. Here the weaving machines are of English and North American make. Winding machines manufactured in the United States are used, and inch measurements are either converted into centimeters or the machines are adjusted to metric units.

Customary units are widely used, likewise, for imports and exports. En route to Brazil the writer interviewed the second officer on the S. S. Boniface (Booth Line), and found that the cargo consisted largely of high-test aviation gasoline, and coal, which was taken on at Phliadelphia for use on Booth ships. The gasoline is shipped in wooden cases, each containing two 5 gallon cans. These are marked in United States units only and are sold all over South America, as oil is not refined there. The officer stated also that crude oil is exported to the United States and is marked in both metric and United States units. From the ship's records the following information was obtained: cargoes from Brazil, the only South American country to which the S. S. Boniface goes, are all in metric units except that wild cat skins are exported by the onça (1.01 ounce), but imports to Brazil are often in customary units. For instance, Port wine from Lisbon, Portugal, is shipped by the hogshead (57 gallons) or pipa (111.8 gallons); Claret by the hogshead (46 gallons) or pipa (115 gallons); Sherry by the hogshead (54 gallons); Madeira by the hogshead (46 gallons); but potatoes and garlic by the kilo. The weight of United States and English machinery and North American cars is given both in pounds and kilos, while coal and cement are imported by the ton. The writer was told by one of the passengers,[18] who has lived for many years in South America that hides and skins are sold from Northern Brazil to the United States and England by the inch, but that leopard and snake skins are sold by the pound.

In Rio de Janeiro bran is exported by the 100 pound bag, the writer found. A tailor shop, which employs fifteen workers was visited here, and the proprietor stated that he imports cloth by the yard from England. For making a suit he allows three yards, but the actual measurements are taken in centimetros (centimeters). In this connection, a secretary at the United States Embassy, reported that dressmakers in Rio de Janeiro measure by centimetros exclusively. At the Lojas

17 The statement of the United Shoe Machinery Company given to Halsey in 1919, still applies to United Shoe Machinery practices. That statement is as follows: "Our company established factories in England, France, Germany, and Austria, and have exported goods and maintained subsidiary companies or branch offices in practically all of the countries of South America.

"In order to maintain uniformity, for such machines as we manufacture both at home and abroad, the English system of measurements is used in all countries so that if necessary machines and parts may be supplied from one country to another." Halsey, Frederick A., *The Metric Fallacy*, p. 59, The American Institute of Weights and Measures, New York, 1919.

18 Mr. Max Goodhart.

Americanas, of which there are five in Rio de Janeiro and eleven throughout Brazil, employing some 250 workers, the manager stated that "yard goods" are imported by the yard, but sold by the metro (meter); dress patterns are sold in United States sizes; and small articles such as: safety pins, buttons, hairnets, and so forth, are imported by the dozen and gross from the United States, Germany, and Japan. Coffee, it was found, is always exported from Brazil in 60 kilo (132.6 pounds) bags, whereas bananas are exported by the cacho (bunch of approximately 9 duzia or dozen). At the factory of the Liceu De Artes E Oficios[19] one of the teachers reported that oil and paints are imported from the United States and England by the gallon and the pint, while steel, brass, and other metals are imported by the ton. The official publication of the Ministry of Foreign Affairs gives banana production and exports in bunches, while "Sericultura" (Silk Culture) gives raw silk imports from Japan in tonelados (1,814 pounds).

The writer interviewed the Director of the Facultad de Ciencias Economicas at the University of Asunción, Paraguay. He stated that wine is imported from the United States and England by the gallon, and oil from Spain by the galón (6.69 pints), while the manager of the Algodones S/A reported that cotton is exported to England in kilos.

In Argentina, a secretary at the United States Consulate stated, cotton and wool are exported by the ton or bale (550 pounds); casein,[20] horsehair, and tallow by the ton; goat skins by the bale; while horsehides as well as other hides are exported by the metric ton (2204.6 pounds). At the Cristalerias Rigelleau, one of the officials reported that the raw materials which this glass factory used, such as sand, if imported from England are bought by the tonelada (0.904 ton), but from France and Germany these imports are by the metric ton (2204.6 pounds). The writer visited also the M. S. Bagley Cia., a large bisquit manufacturing company in Buenos Aires, and was informed that this concern imports in both metric and customary units. Paper and coal are imported by the ton. The manager of the Saint Hermanos Cia., the largest manufacturers of chocolates in the Argentine, stated that cacao beans are imported by the pound from Trinidad and Ceylon, and that the prices are quoted in pounds. In the factory of the Sociedad Anonima Fabrica Argentina De Alpargatas, manufacturers of textiles and canvas shoes, the writer was informed that jute and sisal are imported from Calcutta, India, by the ton.

The writer interviewed one of the secretaries at the United States Consulate in Montevideo, Uruguay, and he reported that: wool is exported by bales, which may vary as much as 50 kilos (approximately 110 pounds), as there is no standard; and that meat is exported by the pound. In the London and Paris Department Store in this same city the writer found that the sizes of ladies' gloves, imported from France, Italy, Belgium, and England, are based on the inch and run from 5¾ to 7¾; imported perfumes are sold by the bottle, regardless of the units by which they were

19 A charity industrial school for boys.
20 The curd matter of milk.

originally measured; while cloth and silk are imported from England, North America, and Japan by the yard. The manager at ANCAP (Administración Nacional de Combustibles, Alcohol, y Portland Cement), the largest industrial company in Uruguay and operated by the government, stated that their exports are sent to the United States and England by the pound; that corn beef, fertilizers, salted hides, pickled lambskins, and salted beef are exported in pounds everywhere, including Europe; that oil is imported in United States units; that crude oil is imported from the United States, Mexico, Venezuela, the Dutch West Indies, and Ecuador by the gallon, while price quotations are by the barrel (52 United States gallons); and that alcohol is imported from Holland by the dram (⅛ of the apothecary ounce). At the store of Castiglioni and Incas-Calcraft, importers, Mr. Calcraft stated that liquors are imported by the botella (bottle), regardless of the units by which they have been originally measured. The writer was informed also at Linn and Company, that their imports: automobiles, machinery, plows, typewriters; dentist chairs, permanent-wave machines, tires, and so forth, are all manufactured in customary units. In the textile and canvas-shoe factory, Alpargatas, the writer found that jute is imported by the bale (approximately 400 pounds).

For river and sea navigation only customary units were found in use in the four countries visited. On the Amazon River, for instance, braça (7.16 feet) is used for taking soundings, while on the S. S. General Alvear which runs between Asunción and Buenos Aires on the Paraná and La Plata Rivers, soundings are taken in pies (0.95 foot) and brazas (5.68 feet). These are customary native measures. The "Buenos Aires Herald" which publishes ship arrivals: British, Italian, American, Finnish, and Japanese, gave the names of the ships together with their tonnage, their cargo, and the names of the firms receiving the cargo; grain shipments also were given in tons. In this connection the manager at ANCAP[21] stated that this company charters Norwegian oil tankers, having a capacity of 9,000 to 15,000 long tons.

Another area in which customary units are used exclusively is that of time. In all the countries visited time is measured as in the United States, by dividing the twenty-four hours into two twelve-hour periods, or as in Europe, by considering the twenty-four hours as one period and using 13 to 24 to designate the hours from 1 p.m. to 12 midnight. Thus 1 p.m. is 13 o'clock, and so forth. In "Brazil—Statistics, Resources, Possibilties," a government publication mentioned above, the legal time in Rio de Janeiro is given as 7 minutes, 6 seconds behind Greenwich time.

Temperature in the countries investigated is measured either by centigrade units or Fahrenheit, or both. In Montevideo, Uruguay, the writer saw several outdoor thermometers, which had both the Fahrenheit and centigrade scales. Inquiries were made in a store, Pablo Ferrando which deals in optical, photographic, and hospital supplies, and the writer was informed that all the thermometers which this company carries, have both scales.

21 Administración Nacional de Combustibles, Alcohol, y Portland Cement.

ANCAP[22] in the production of alcohol uses the Fahrenheit scale more than the centigrade the writer was told. The Bagley Biscuit Company in Buenos Aires, Argentina, however, uses only Fahrenheit thermometers.

Customary weights and measures, also, were found by the writer to be taught in the schools of Brazil, Argentina, and Paraguay. At Santarém, Pará, in northern Brazil, the Collegio Jesus Maria José, Escold Particular Mixte (a private school for boys and girls) was visited. About fifty pupils attend this school. The Headmistress stated that only metric weights and measures are taught but that the boys know the common customary Portuguese units because these are used in the market. The arithmetic book which the children use gave the following:

"The System of Measures Adopted in Brazil"

"In Brazil the metric system has been adopted with some alterations, for there have been adopted, also, some measures of the customary system, the relations of some of which to the metric system have been defined in metric units, and some of which have not been defined in metric units."

A table which was given indicates that the libra is the customary Portuguese and Spanish pound; that the pollegado, pé, and palmo are the customary Portuguese units; and that the others such as: the quilate, the onça, alqueire, and milha, closely approximate the customary Portuguese units, while the oitava differs by only 1½ grains and the pipa by one gallon. The canada is 1/3 larger.

In Paraguay the Director of the Colegio International at Asunción, stated that in the primary grades the boys are taught only metric units but that in higher mathematics they deal with the customary weights and measures, also, and learn to use conversion tables.

The writer interviewed an inspector in the Buenos Aires public schools. He reported that in the Argentine schools both metric units and the English system are taught.

A careful tabulation was made of the writer's data, gathered from 31 places visited or contacts made in the interior, and from 73 places visited or contacts made along the coast, a total of 104. Of these 104 visits or contacts made, 18 were rural and 86 in cities.

The writer's conclusions based on the above findings are:

1. That in spite of compulsory metric laws; government inspection; and penalties of fines or imprisonment, or both, for any infraction of these laws, the customary weights and measures which are most convenient and so have become a part of the people's thinking, such as: the inch, the pound, the foot, the arroba (25.35 pounds),[23] and the palmo (8.66 inches), are still used regularly in trade and industry in the four South American countries in which this field study was made—Brazil, Argentina, Uruguay, and Paraguay.

2. That more than one-third, approximately 35%,[24] of the units in use in trade and industry in these countries are customary weights and measures. Obviously this is not in-

22 Administración Nacional de Combustibles, Alcohol, y Portland Cement.

23 Spanish.

24 Halsey, *op. cit.* The writer tabulated also the data for Brazil, Argentina, and Uruguay of this earlier questionnaire study. Halsey's per cent of customary usage was approximately 44%.

consequential because the use of metric units has been compulsory here for from seventy to ninety years.

3. That some further effects of the compulsory use of metric units are:

a. A mixed system of weights and measures (metric, English, and Spanish or Portuguese). In this connection it should be pointed out that the metric units never have been used exclusively, even in France, where the customary tonneau de jauge or gageton (100 cubic feet) has been adopted officially,[25] together with customary units of time, angles, and navigation, as well as many modified units such as, the demi-kilogramme and the double-metre,[26] which are permitted to meet the requirements of the law and yet allow the people to think in customary units.

b. Confusion in thinking.

c. Much useless labor in calculating and using conversions.

d. Disregard of the laws in the interior and in rural districts, and evasion as well as disregard in urban centers.

e. A great amount of social and private cost to:

(1) The governments, for inspectors and enforcement of unpopular laws which are either ignored or evaded as much as possible;

(2) Business, industry, and trade for calculating conversions, and for machinery equipped with both customary and metric gages and devices.

f. Increased difficulty in education, due to the mixed system of weights and measures.

4. That customary units are still used to a considerable extent in the measurement of land because:

a. They are better suited to this purpose.

b. They are an integral part of the people's experience and thinking, and so can be visualized—an important factor in buying and selling real estate, particularly cattle-breeding and farm lands.

c. They have been used in original deeds and, therefore, must be known and understood.

5. That the use of customary units predominates for machinery and tools, most of which are imported from the United States or England.

6. That timber and lumber which come from the interior or from the rural districts are measured, in general, by customary units.

7. That imports and exports are weighed and measured by customary units, for the most part, if they come from or are going to non-metric countries. In other words, the units used depend, in general, upon the place of origin or the destination of the goods.

8. That compulsory metric usage varies in direct proportion to the strictness of government inspection; the enforcement of the laws; and the severity of the penalties.

The reader may now ask, "Why do customary weights and measures continue to be used in the countries investigated in disregard of the laws and in spite of severe penalties?" There are a number of reasons, the most important of which are:

1. Because most of the people prefer them, since they are more convenient, having a practical relationship of units, due to the fact that they have developed through the process of natural selection. Furthermore, they are

25 Kennelly, Arthur E., *Vestiges of Pre-metric Weights and Measures Persisting in Metric-system Europe 1926-1927*, p. 53, The Macmillan Company, New York, 1928.

26 Demi-kilogramme (livre or pound). Double-metre (toise or fathom).

more adaptable to everyday needs and to ordinary industrial and business requirements as they may be multiplied and divided not only decimally, but binarily and duo-decimally.

2. Because compulsory metric laws cannot be enforced completely. Confiscation of weights and measures, fines, and imprisonment have not exterminated ingrained habits of thinking and speaking in customary units.

3. Because many of the industries in these countries have been developed by the English and by North Americans.

4. Because manufacturing to a great extent there has been developed by the English and by North Americans.

5. Because international trade is carried on largely in the English system.

6. Because they have proved to be better adapted to river and sea navigation.

7. Because they are unquestionably superior for measuring time.

Or the reader may ask, "Does the metric substitute plan operate as a system with most of the well-advertised benefits such as, economy in calculations and ease of learning?" The answer is that it does not because:

1. Only a few isolated metric units such as: the kilo (½, ¼, ⅛), the centimeter, the meter (½, ¼, ⅛, 1/16, ¾), the liter (½, ¼), and the ton, which approximate convenient customary weights and measures, are actually used to any extent.

2. Supplementary customary units such as: the arroba (25.35 pounds),[27] the palmo (8.66 inches), the braza (5.68 feet), the vara (2.84 feet), and so forth are commonly used, necessitating conversions which increase the amount of calculating.

3. The resulting mixed system (metric, English, and Spanish or Portuguese) makes learning in the field of weights and measures more complicated and difficult for children in school.

The reader will doubtless wish to know, also, what modifications or adaptations of metric units occur. They are as follows:

1. The use of binary fractions such as: ½, ¼, ⅛.

2. The use of double units and other multiples such as: the double-liter, 5 liters, and 10 liters.

3. Using additional customary units, legalized in metric values such as: the arroba metrica (33.3 pounds); the quilate metrico (3.086 grains); and the tonelade metrica (2204.6 pounds).

The writer cannot bring this discussion to a close without emphasizing two important implications of this investigation. The first has to do with the still controversial question of whether or not metric usage should be made compulsory,[28] enforced by penalties, in the United States. The evidence is conclusive that such compulsory legislation would be a great mistake because:

1. The use of twenty-eight metric weights and measures has been permissive for the past seventy-five years, and yet they have made no headway on merit, except in the chemical laboratory.

2. The uniformity of the English system would be lost, and a mixed system would result, causing confusion

27 Spanish.

28 See the writer's review of the Twentieth Yearbook of the National Council of Teachers of Mathematics, *Education*, 69:662, June, 1949.

and useless expense, such as have been experienced in South America. Furthermore, because the United States is a highly industrialized country, the confusion and expense of a forced change to metric units would be much greater than in South America which was little developed industrially when the change was attempted there about 1862.

The second implication has to do with the educational question of teaching the metric system in the schools of the United States. The evidence beyond any doubt makes clear that it should not be taught as a basic system which will ultimately replace our present one, for the following reasons:

1. The metric system as such exists only on paper. Actually in use there are a few isolated units, together with their halves and quarters.

2. The twenty-eight metric weights and measures which were legalized in the United States in 1866 are used scarcely at all except in laboratory work, where the gram and the cubic centimeter are convenient. For such specialized work these particular units should be taught when needed.

3. The advantages claimed for metric weights and measures are pure academic theory. In practice they have more disadvantages than advantages; some metric units are ill-adapted and inconvenient.

4. A nation's weights and measures like its language cannot be taken away and replaced overnight.

Therefore there should *not* be any systematic teaching of the metric "system" in the schools of the United States; it is at most merely reference material.

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Why *the* Metric System Didn't Work *as a* System

By WILLIAM E. BULLOCK
Fellow of the American Association for the Advancement of Science

Editor's Note: This and the article which precedes it, "Weights and Measures in South America," may also be used as introductory material for an appreciation unit in mathematics.

THE title of this article was given me as a suggestion, and my first reaction was to change it, for I found myself asking such questions as: "As a System of What?", "As a System of Numbers?", "As a System of Units?", "As a System of Related Units?", As a System of Prefixes?", "As a Political System?", 'As a System of Practical Unit Quantities?", and so on.

My second reaction was not to change the title, but to point out that the first word "system" in it may have, and indeed does have, an entirely different connotation from the second word "system," for the "metric system" is a set of words, figures, signs, and abbreviations—a few words with a series of prefixes, decimal figures, signs to indicate in which groups the words belong, and abbreviations to enable the notations to be written conveniently. The whole system can be printed in about 35 lines of type, in tabular form, and can be learned by an average child in one short lesson in the arithmetic class. The metric system was invented during the French Revolution. It was based on an attempt to derive a working unit and standard of length from some invariable quantity in nature; to relate this unit and standard of length to a working unit and standard of mass; to provide simple names for the units of length, weight or mass, capacity, area and volume; to add uniform prefixes to the basic names to indicate multiples and sub-multiples; and to name decimal multiples and sub-multiples exclusively. Almost at its inception, the metric system became a subject for political action. It therefore became a political system, and so the title of this article can be construed, "Why the Metric System Didn't Work as a Political System?"

The metric system came into being at a time in which international action was being sought not only in the field of weights and measures, but also in that of coinage. The first germ of such action developed not in France but in this country. Originally, and for a long period, the American people used the English monetary terms most extensively, and also the English units of weight and measure. The idea annexed to the pound sterling, shilling, and penny, and the yard, pound avoirdupois, gallon and bushel, however, were almost as various as the states themselves. The Continental

Congress became concerned particularly over the variations in the coins, and in 1778 appointed a committee to consider the question and report from time to time.

In 1782 Robert Morris, Superintendent of Finance, believing it necessary for the country to have a standard of its own by which to estimate the various coins current, recommended the adoption of an American coin, and, in view of its scientific advantages, a decimal system of numeration. At the same time Jefferson added some notes favoring the application of the decimal system not only to money but also to weights and measures. Jefferson's decimal plan, elaborated by the genius of Hamilton, was adopted by Congress in 1792. The law decimally subdividing the dollar thus antedates by a few years the establishment of the metric system in France. The latter originated in France in 1790, but it was nine years before the prototype meter of platinum was constructed by an international commission representing the governments of France, Holland, Denmark, Sweden, Switzerland, Spain, Savoy and the Roman Cisalpine and Ligurian Republics.

The progress of the metric system of weights and measures was slow both inside France and outside it. Its advantages, however, as a political system suggested themselves to leading statesmen at the same time that these advantages were being utilized for more practical purposes by men of science. But unfortunately, as already noted, the politics of weights and measures became linked up with the politics of money. The result was an impasse which delayed the full adoption of the metric system in France for about fifty years, and undoubtedly prevented its full adoption in this country for all time.

At the International Exhibition held in London in 1851, the two questions were still linked, and scientific assemblies there discussed extensively a common system of weights and measures and coins. Nothing was accomplished, however, though at the close of the Exhibition the London Society for the Encouragement of Art, Industry, and Commerce informed the government that it would be well to consult the neighboring nations to see if steps could not be taken to hasten the adoption of a uniform system of coinage, weights and measures for the entire world. Parenthetically, the words "coinage, weights and measures" used in conjunction have a familiar ring in this country as they appear thus linked in our Constitution.

The International Statistical Congress held at Brussels in 1853 debated the subject still further, but could not agree on any proposal. At the next Statistical Congress, held in Paris two years later in connection with the Exposition, Louis Napoleon, who had shortly before been declared Emperor, used his efforts to secure the extension of the metric system of weights and measures and also of coins; but here also there was failure to agree upon a plan of concerted action, though a large number from the juries and committees of the different countries signed a declaration strongly urging uniformity in weights, measures, and coins.

Informed of these facts, and observing the active agitation of the subject by the Decimal Association in England, our Congress revived the issue and in 1856 passed a joint resolution directing the Secretary of the Treas-

ury to appoint a commissioner to confer with the proper functionaries of Great Britain; but nothing came of it.

Then our country became involved in the throes of Civil War. Although our specie disappeared from circulation completely, it continued as a subject of consideration and discussion, and only a few days before the government suspended specie payments, Salmon P. Chase, Secretary of the Treasury, in his annual report, invited the attention of Congress to the importance of uniform weights, measures, and coins, and to the worth to the world of the decimal system.

It was not until 1863, at another Statistical Congress held in Berlin, that a definite proposal was made to "break the political link" between weights and measures on the one hand and coinage on the other, and to convene the first congress at which the problem of uniform coinage was considered exclusively. The United States sent Samuel R. Ruggles, a leading member of the New York Chamber of Commerce, as its delegate. Ruggle's principal suggestion was that both the English sovereign and the American half-eagle be reduced to the value of 25 French francs. Dr. Farr, Register-General of the United Kingdom, had provoked this suggestion with the proposal that the gold dollar of the United States be made equal to one-fifth of the English sovereign. Ruggles' suggestion broke up the Congress, but had Farr's proposal gained the day it would have changed the course of money history.

The Congress did actually change the course of metric-system history, as thereafter weights and measures became the subject of a series of international conferences independent of coinage conferences; but this specific and independent consideration was a half century too late politically. Congress did not legalize the use of the metric system of weights and measures in this country until 1866, and it undoubtedly did so then only to forestall the impact of future "international conferences," particularly "Napoleonic conferences" which were beginning to be "too effective" in the money area.

Some day a history may be written of "the metric system as a source of political power." This is an excellent thesis subject. Ample information on which to base it is available in the library of Columbia University, New York City, in the form of a collection made by the late Samuel S. Dale, of Boston, Massachusetts, a lifetime collector of data on the subject. Mr. Dale was one of the most prominent opponents of the movement for the compulsory adoption of the metric system of weights and measures in the United States which began about 1896 and resulted in the Act of Congress of 1901 setting up the National Bureau of Standards to "have custody of the standards of weight and measure." For many years the Bureau worked sub-rosa to advance this compulsory adoption, but of late has contented itself with declaring that the "meter and kilogram are the fundamental units of length and mass." The declaration is quite harmless as Congress has *never adopted any standards of length and mass.*

DEPARTMENT OF BOOK REVIEWS

Liberal Education for Free Men. By Thomas Woody. Philadelphia. University of Pennsylvania Press. 1951. IX and 296 pages. $4.00.

Professor Woody describes the ideals and practices of educators in different lands and in different epochs in this interesting study of the nature and the goals of liberal education. A first chapter is devoted to the little-known Chinese emphasis on the six virtues, six good actions, and the six arts. A second chapter considers the Athenian principle of the mean, with its balance and interdependence of mental and physical exercise. The development of education in the Roman Republic and Empire leads into a consideration of Western thought and liberal learning during the Age of Faith and during the Renaissance. In the concluding chapter, Professor Woody discuses major educational problems of our era—the question of liberal versus vocational education; the confusion existing in present thinking on the content of liberal education; and the political implications of the education proper for free men.

— WILLIAM P. SEARS

Modern Physics. By Charles E. Dull, H. Clark Metcalfe, and William O. Brooks. New York. Henry Holt and Company. 1951. $3.48.

This new edition of *Modern Physics* takes into consideration the developments in physics during the last few years. This means much new material on electronics, nuclear energy, radar, and television. The method of inductive approach is used and the steps followed involve (1) statement of a topic or the presentation of a question (2) association of the problem or question with some incident familiar to the student (3) discussion and explanation of the physical principles in language simple enough for a beginner to understand and (4) the use of one or more applications to show the way in which the principle is utilized. Such a method, the authors declare, arouses interest. The book is comprehensive and presents a tremendous amount of material from which the careful teacher can fashion his course of study. — WILLIAM P. SEARS

Essentialism. By Frederick Mayer. London. Hampton Hall Press. 1950. 223 pages.

Frederick Mayer, Associate Professor of Philosophy at Redlands University in California, considers some of the most perplexing problems of the day in this little book. It is his major contention that the primary problem of thought is man and his institutional relationships. Briefly, the professor defines essentialism as a unification and universalization of knowledge and an attempt to apply it concretely and experimentally to the problems of society. The book is written for the intelligent layman rather than for the scholar.

— WILLIAM P. SEARS

The Development of American Industries. By John George Glover and William Bouck Cornell. Third Edition. New York. Prentice-Hall, Inc. 1951 XXVII and 1121 pages. $8.00.

The third edition of the now standard classic work on American industry is a completely revised and up-to-date book. Forty-one industries are analyzed and described in detail and each chapter has been prepared and written by a leading industrialist. Three new chapters have been added and these deal with the aluminum, the magnesium, and the pharmaceutical industries. "Glover and Cornell" brought up to the minute will be welcome news for librarians and for instructors and professors in the appropriate fields. — WILLIAM P. SEARS

The Teaching of Arithmetic. Fiftieth Yearbook of The National Society for the Study of Education, Part II. Edited by Nelson B. Henry. Chicago. The University of Chicago Press. 1951. xii and 297 pages. $2.75.

After 22 years the National Society for the Study of Education has published another yearbook on arithmetic. Its purpose is to present: (1) changes in "theoretical concepts" due to more recent investigations in the psychology of learning; and (2) new implications arising out of changing conceptions of the social values of arithmetic together with its relation to other subjects. The book contains chapters on the teaching of arithmetic for preschool children, and elementary and junior high pupils. There are also chapters on the psychology of learning in relation to the teaching of arithmetic, instructional materials, and testing instruments. Three or four chapters are devoted to teacher education. The contributors have done a good job of covering the teaching of arithmetic on the symbolic level. Unfortunately, however, the treatment is decidedly weak on the pre-symbolic level. Now, the foundation of a genuine understanding of symbolic arithmetic lies in the pre-symbolic area—in the world of objects. There is much demand for meaningful arithmetic but here we have another superb building without a foundation. This is doing the same thing over again without doing it better.

At the symbolical level there are some details worthy of comment. Pictures are useful but the illustration on page 31 of dividing a group of 12 objects into thirds is difficult to understand. The treatment on page 46 is much better for multiplication. The comparison on page 53 is one of the few places in which pre-symbolic arithmetic is mentioned and indorsed. The treatment of number readiness, pp. 54 and ff., is good but is presented entirely on the symbolic level. "Addition is a process of putting together." (p. 65) This is true of discrete objects but hardly covers addition related to change as in a thermometer and speedometer. The idea of "putting together" in these areas is rather subtle for child understanding. "Subtraction" is a process of taking apart or separating." (p. 65) This excludes additive subtraction. For example, suppose Joe has three color crayons and needs eight. He wishes to know how many more crayons to get. This has nothing to do with "taking apart" or "separating." "Multiplication is a process of adding (putting together) of two or more groups of the same size to form one larger group." This is the multiplication of times taking. It does not include the multiplication of manifolding as in finding the areas of rectangles or buying supplies at so much a pound. "Division is a process of separating (taking apart) of a larger single group into two or more equal sized groups." This is partition in which the quotient is a concrete number. There is another sort in which the quotient is an abstract number. So as to definitions of processes the yearbook treatment scores only 50% correct.

The treatment of the fraction multiplier (pp. 89 and 94) is unusually good. The meaning of ratio (p. 98) is developed well but is confined to the symbolic level.

The chapter on arithmetic in the junior-senior high school fails to deal with that needed in algebra and other high school subjects. It thus tends to perpetuate the unfortunate chasm which exists in mathematics between the elementary and secondary levels.

In the chapter, "The Psychology of Learning in Relation to the Teaching of Arithmetic," the "organism as-a-whole" point of view is ignored. Only eight lines are devoted to the psychology of the learner.

The chapter, "Instructional Materials for Teaching Arithmetic," is excellent but there is too little guidance for the teacher. She will be puzzled to know the purpose of some of the materials. Unless she is able to secure all of them she will be at a loss to know which ones will best meet her needs.

In spite of a few omissions the book is an excellent discussion of symbolic Arithmetic. It should be in the professional library of your school. — WORTH J. OSBURN, Professor of Education, University of Washington.

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